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ABSTRACT

This manual, the third of three curriculum guides for an electronics course, is intended for use in a program combining vocational English as a second language (VESL) with bilingual vocational education. Ten units cover AC fundamentals, circuit protection devices, low voltage circuits, communication systems, graphic illustrations, house wiring, electrical energy and power, inductance, capacitance, and R, C, and L circuits. A lesson plan is provided for each lesson within the unit. Components include teaching materials sources, main concepts (objectives), teaching activities, materials and notes, length of lesson, and evaluation. Other contents of each unit include handouts, such as informational material, homework/assignments, lab experiments, unit tests, glossaries of technical and related general vocabulary, and Vietnamese and Cantonese translations. Numerous drawings and diagrams illustrate the text. (YLB)

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ELECTRONICS BOOK III

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Elk Grove, CA

September 1986

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ELECTRONICS

BOOK III

UNITS

I.	A.C FUNDAMENTALS	1 week
II.	CIRCUIT PROTECTION DEVICES	2 - 3 days
III.	LOW VOLTAGE CIRCUITS	2 - 3 days
IV.	COMMUNICATION SYSTEMS	2 - 3 days
V.	GRAPHIC ILLUSTRATIONS	2 - 3 days
VI.	HOUSEWIRING	1 day
VII.	ELECTRICAL ENERGY & POWER	2 - 3 days
VIII.	INDUCTANCE	3 weeks
IX.	CAPACITANCE	2 - 3 weeks
X.	R,C, & L CIRCUITS	2 weeks

SECTIONS

1. Lesson Plan
2. Teaching Materials
3. Homework/Assignments
4. Lab Experiments
5. Tests
6. Technical Glossary*
7. Related General Glossary*
8. Vietnamese Translations
9. Cantonese Translations

*to be completed

ELECTRONI CURRICULUM
VOCATIONAL TRAININ SSON PLAN 1 AC Fundamentals

Teaching Materials Source ____________________
Chapter ____________, pages ____________
Lab Manual pages ____________
Additional Instructor Materials ____________________

Main concepts student will learn:

1. explain the electrical difference between AC and DC, and describe the operation of a simple AC generator.
2. determine the average and/or effective value of an AC sine wave when its peak or peak-to-peak value is known.
3. compute the period, instantaneous voltage, and wavelength in a given problem utilizing the proper formula and unit of measurement for each quantity.
4. analyze and solve AC circuit problems for E, I, R or P in circuits which contain only resistance.
5. draw wave forms which depict both "in phase" and "out of phase" relationships between voltage and current in a circuit.
6. identify the audio and radio ranges of frequency within the frequency spectrum, and describe the function that the F.C.C. performs in terms of frequency regulation.

Technical Vocabulary

see Glossary

Related General Vocabulary

Teaching Activity

see attached

Length of Lesson

1 week

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Materials and Notes

1. Construct and discuss on the blackboard a mock electric power transmission system. Include a power plant, a control center, transmission facilities, distribution lines and devices for increasing or decreasing the voltage.
2. There are several simple motor or generator kits that are commercially available, which may be selected as a laboratory supplemental type activity at a very nominal dollar amount.
3. A variety of communication devices in the laboratory should be available for display or demonstration. They could be arranged with labels to indicate the chronological sequence of development such as a telegraph, telephone, crystal radio, AM radio, etc.

TEACHING ACTIVITY

Methodology: Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. This unit can have a tendency to be dry and students can mentally wander during instructor presentations so draw upon the many opportunities to demonstrate principles related to communicating, power, historical AC experiments, motors and generators, and waveforms.

2. Try this activity before a lecture and it will guarantee student excitement about AC. Utilizing a microphone connected to a scope, call up a student to sing into the microphone and then observe the waveform generated with the class. A radio tuned to a popular local station with the scope monitoring the signal at the speaker will serve as a natural "turn on" prior to a discussion on waves. communication, etc.

3. Utilizing the "Spell Down" game strategy previously presented in Unit 6 have students spell and define the words in their glossary.

4. Contact the local electric power company in your area and ask that a representative speak to the class about the reasons for the use of alternating current and to explain how the company meets peak power demand.

5. Formulas can be cumbersome in this unit so concentrate on explaining the function of specific magnitudes when examining AC values in order to accomodate student learning.

6. List a variety of appliances on the blackboard or overhead and have the class categorize them according to the type of voltage necessary to operate them. Then examine the possibility that the type of voltage within the appliance may have been converted and the reasons why this may have occured.

7. In addition to formal laboratory experiments, certain laboratory presentations can assist the instructor in vividly illustrating the shape and characteristics of AC sine waves, and the audio frequency band. During an appropriate lecture or discussion use a classroom oscilloscope, signal generator, and signal tracer to enhance the students understanding of technical concepts. Inject signals and observe both the audio/visual affect, then discuss outcomes with the class.

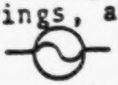
Name: ____________

Date: ____________

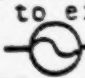
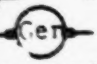
Period: ____________

AC FUNDAMENTALS

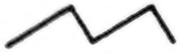
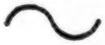
TECHNICAL GLOSSARY

ALTERNATING CURRENT:	A flow of electrons which move first in one direction, stop, and flow in the opposite direction. Current, flow begins at zero, increases to a positive maximum, decreases to zero, then increases to a negative maximum and again decreases to zero. The alternating current signal is depicted as a sine wave: ∿ Abbrev. AC
ALTERNATION:	One-half of an AC wave or cycle, beginning at one zero point, and ending at the next zero point. Consists of the complete rise and fall of an AC voltage or current in one direction. The positive alternation begins at 0° and ends at 180°. The negative alternation begins at 180° and ends at 360°. Graphically ⌒ or ◡.
ALTERNATOR:	An alternating current generator that utilizes a stator, rotor, slip rings, and brushes to produce electricity. Symbol:  Letter symbol: GEN
AMPLITUDE:	The vertical size or height of an alternating current wave; commonly measured either from the zero line to one maximum point, or from the negative maximum point to the positive maximum point.
ARMATURE:	The rotating windings of a generator in which the voltage is produced. Each winding terminates at a commutator segment, or slip rings.
AUDIO FREQUENCY:	A group of AC frequencies that can be heard as sound waves by the human ear. The range of audio frequencies is approximately 20 to 20000Hz. Abbrev. AF
AVERAGE VALUE:	An arithmetical average of all the values on a sine wave for one alternation. Equivalent to .637 x peak value. Abbrev. AVG
BAND:	A group of adjacent frequencies. For example: The AM radio band encompasses frequencies from 535 kHz to 1605 kHz.
BRUSH:	A sliding contact, usually made of carbon, used to make connections to a rotating commutator or slip ring.
COMMUTATOR:	A ring of copper segments, insulated from each other and used to terminate the armature windings. The brushes ride on the commutator.
CYCLE:	One complete alternating current wave from 0° to 360°. One cycle consists of 2 alternations, one positive and one negative.

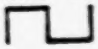
Name: ______________________

DISTORTION:	A change in the expected wave shape or form due to a deviation in amplitude, phase, or frequency - usually considered undesirable.
EFFECTIVE VALUE:	The most common method of measuring an AC value, and expressed in formula form .707 x peak value. Also known as the root-mean-square value (RMS). Abbrev. EI
ELECTROMAGNETIC INDUCTION:	The process of producing a voltage in a wire by either passing the wire through a magnetic field, or by movin the magnetic field past the wire.
FEDERAL COMMUCICATION COMMISION:	A U.S. Government agency which is in charge of regulating and assigning use of the frequency spectrum. Abbrev. FCC
FIELD WINDING:	A set of windings in a generator which is supplied wit a D.C. voltage to produce an electromagnetic field.
FREQUENCY:	The number of complete A.C. waves or cycles which occu during a particular amount of time, usually one second Measured in the basic unit hertz. Symbol: f
GENERATOR:	A machine used to produce electricity by causing one, or a series of interconnecting coils to either cut or be cut by a magnetic field. Symbol:  or  Letter symbol: GEN
HARMONIC:	A multiple frequency of a base wave or frequency. For example: If 100Hz is the base frequency, then 200Hz the second harmonic, 300Hz is the third harmonic etc. Harmonic frequencies are generally lower in amplitude than the base frequency.
HERTZ:	The basic unit for frequency, and it is the equivalent to the number of complete AC cycles occuring in one second. Also referred to as cycles per second (cps). Example: a frequency of 60 hertz means that 60 comple sine waves occur per second. Abbrev. Hz
INSTANTANEOUS VALUE:	The value of an alternating current or voltage at any specific instant in a cycle-commonly expressed in degrees. Instantaneous value = sine x peak value.
INVERTER:	An electric or electronic device which converts direct current to alternating current.
LEFT HAND RULE:	A method for determining the direction of current flow in a conductor. Extend the thumb, first finger, and second finger of the left hand at right angles to each other. Point the thumb in the direction of conductor motion; the first finger in the direction of the magnetic field (from north to south); then the second finger will indicate the direction of current flow.

Name: ____________________

NONSINUSOIDAL:	Any wave form that is not a sine wave. For example a square wave (⊓⊔) is a nonsinusoidal wave.
OSCILLATOR:	An electronic device which converts DC energy into AC energy.
PEAK-TO-PEAK VALUE:	The total amplitude or measurement of an AC wave from the positive maximum point to the negative maximum point. Abbrev. p-p
PEAK VALUE:	The measurement of an AC wave from the zero line or point to the maximum positive or maximum negative point. Abbrev. PK
PERIOD:	The time, in seconds, that it takes to complete one AC cycle. Period = $\frac{1}{\text{Frequency}}$. Letter symbol: T
PHASE:	An angular comparison of the starting and ending points of two or more AC waves. To be of any significance the waves must be of equal frequency.
PHASE ANGLE:	The angular difference between the voltage and current waves of an electronic circuit.
RADIO FREQUENCY:	Frequencies located between the audio band and infrared light on the frequently spectrum, generally between 10kHz and 300,000,000kHz. Radio frequencies have the ability to travel or radiate over long distances, and usually cannot be heard. Abbrev. RF
ROTOR:	The rotating part within an alternator. Generally, containing a coil of wire terminating at the slip rings and used to provide a magnetic field.
SAWTOOTH WAVE:	A waveform resembling the teeth of a saw. The wave represents a voltage or current that slowly increases (at a uniform rate) and then drops sharply to its starting value. Example:  Represents 2 cycles.
SINE WAVE:	The waveform produced by an AC generator. The amplitude of the wave is proportional to the sine of the angle between the magnetic field and the positions of the rotating armature. Example:  Represents 1 cycle.
SINUSOIDAL:	Referring to a wave or circuit output that follows the shape and form of a sine wave.
SLIP RINGS:	Two insulated copper rings used as the sliding contact between the brushes and the rotor winding of an alternator.

Name: ____________________

SQUARE WAVE:	A waveform that contains a positive and negative alternation which are square in shape. The square shape indicates that the voltage or current raises immediately to its maximum value and remains at that value for the duration of the alternation. The wave then immediately changes in polarity. Example:  Represents one cycle (2 alternations).
STATOR:	The stationary coils of an alternator in which the voltage is produced or induced.
WAVEFORM:	The pattern or shape of a wave derived from graphing the instantaneous values of a voltage (or current) on an x-y axis. The x axis is designated as "time" while the y axis represents "amplitude."
WAVELENGTH:	The distance a wave travels from the beginning point to the end point of one cycle, or the distance between corresponding points on two adjacent waves. Wavelength $= \frac{\text{velocity}}{\text{frequency}}$. Letter symbol:

SCORE:

GRADE:

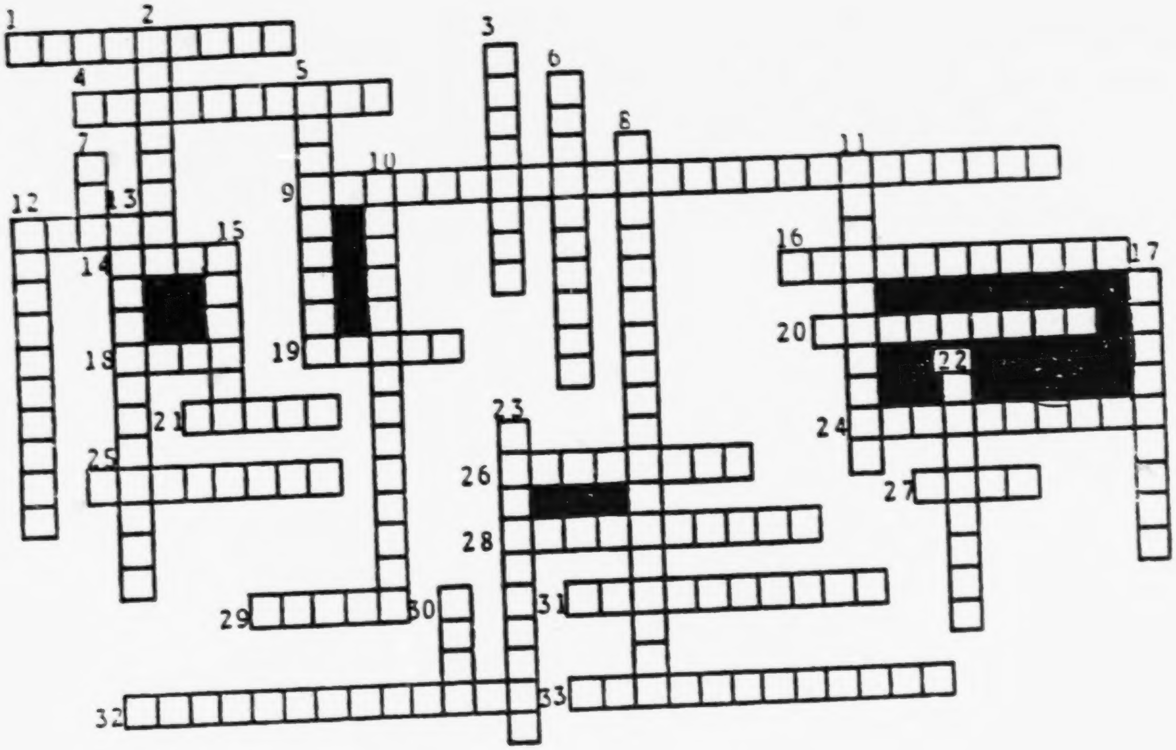
Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - CROSSWORD PUZZLE



ACROSS

1. The height of an alternating current wave.

4. The distance an AC wave travels in one cycle.

9. Producing a voltage in a wire by moving the magnetic field past a wire. (2 wds)

12. Consists of 2 alternations, one positive and one negative.

14. Abbreviation for root mean square value.

16. Consist of a complete rise and fall of an AC voltage or current in one direction.

18. Basic unit for frequency.

19. The rotating part within an alternator.

20. The number of complete AC cycles produced per second.

21. A sliding contact, usually made of carbon.

24. An electronic device which converts DC energy into AC energy.

Name: ____________________

Date: ____________________

Period: ____________________

25. The windings of a generator in which voltage is produced.

26. A multiple frequency of a base wave or frequency.

27. The measurement of an AC wave from the zero line to the positive maximum point.

28. A wave, or circuit output, that follows the form of a sine wave.

29. An angular comparison of the starting and ending points of 2 or more AC waves.

31. The total amplitude of an AC wave from the positive maximum point to the negative maximum point.(3 wds)

32. Any wave form that is not a sine wave.

33. Is equal to .637 x peak value.(2 wds)

DOWN

2. Converts direct current to alternating current.

3. A wave representing a voltage that slowly increases and then drops sharply to its starting value.

5. A machine that produces electricity by causing a series of interconnecting coils to cut through a magneticfield.

6. A nonsinusoidal wave form that contains a positive and negative alternation.(2 wds)

7. Federal Communication Commission Abbreviation.

8. ________ = sine x peak value
(2 wds)

10. Equivalent to the root mean square value.(2 wds)

11. A change in the expected wave shape due to a deviation in amplitude, phase, or frequency

12. A ring of copper segments use to terminate the armature windings.

13. A method for determining the direction of current flow in a conductor. (3 wds)

15. Part of an alternator which performs the same job as the armature in a generator.

17. Two insulated copper rings used as the sliding contact between the brushes and the rotor winding.(2 wds)

22. Wave form produced by an AC generator.(2 wds)

23. Angular difference between voltage and current waves in an electronic circuit.(2 wds)

30. A group of adjacent frequencies.

Name:________________

Date:________________

Period:________________

SCORE:

GRADE:

WORKSHEET

AC VALUES

Solve the following conversion problems. Always include the unit of measurement, and the AC value, in your answer. For example: 10V p-p

unit of measurement AC value

1.

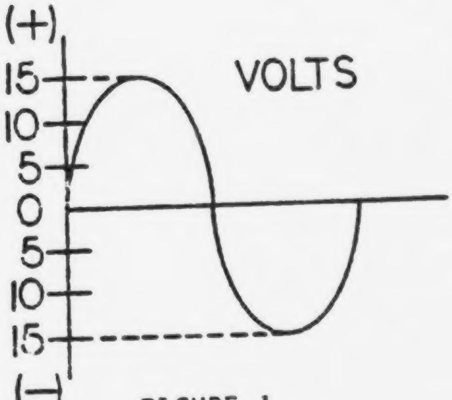


FIGURE 1

A. What is the peak to peak value of the sine wave in figure 1?

1A.

B. What is the peak value of sine wave 1?

1B.

C. Determine the average value of the sine wave.

1C.

D. Compute the effective value of the sine wave.

1D.

....

2.

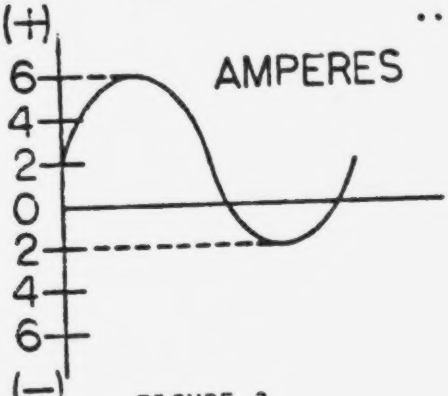


FIGURE 2

A. Determine the peak value of the sine wave in figure 2.

2A.

B. What is the average value of the sine wave?

2B.

C. Find the peak to peak value of sine wave 2.

2C.

D. Compute the RMS value of the wave.

2D.

3. $E = 30V_{p-p}$--Convert to peak value.

3.

Show work

4. $E = 40V_{PK}$--Find the peak to peak value.

4.

Show work

Name: ____________________

Date: ____________________

Period: ____________________

5. ☐

5. $I = 5A_{PK}$--Find the average value.

Show work

6. ☐

6. $I = 33mA_{PK}$--Convert to effective value.

Show work

7. ☐

7. $E = 117V_{RMS}$--Solve for peak value.

Show work

8. ☐

8. $I = 6A_{EFF}$--Find the RMS value.

Show work

9. ☐

9. $E = 40mV_{p-p}$--Find the average value.

Show work

10. ☐

10. $I = 10A_{p-p}$--Find the effective value.

Show work

11. ☐

11. $E = 20V_{EFF}$--Convert to peak to peak value.

Show work

12. ☐

12. $I = 7A_{EFF}$--Convert to average value.

Show work

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

ALTERNATING CURRENT PRINCIPLES

MATCHING

In the exercise below, the lettered answers may be used more than once.

Column 1 (Question)	Column 2 (Answer)	Letter chosen from column 2
1. Direct Current	A. Part of an alternator	1. ☐
2. Alternating Current	B. 90°	2. ☐
3. Inverter	C. Source of alternating current	3. ☐
4. DC Generator	D. Flows in only one direction	4. ☐
5. Solar Cell	E. Left Hand Rule	5. ☐
6. Alternator	F. Cycles per second	6. ☐
7. Oscillator	G. 50 Hertz	7. ☐
8. Battery	H. Radio Frequencies	8. ☐
9. Piezo electric crystal	I. Flows first in one direction stops, and flows in the opposite direction	9. ☐
10. Thermalcouple	J. Source of direct current	10. ☐
11. Most common form of electricity	K. Audio Frequencies	11. ☐
12. Stator	L. AC	12. ☐
13. Field winding	M. Part of a DC generator	13. ☐
14. Brushes	N. 180°	14. ☐
15. Indicates direction of current flow in a conductor	O. Hertz	15. ☐
16. Zero point on the sine wave.	P. Sliding Contact	16. ☐
17. Maximum positive point on sine wave	Q. 60 Hertz	17. ☐
18. Preferred unit for measuring frequency		18. ☐
19. Frequency of AC power in the USA		19. ☐
20. 20-20,000 Hertz		20. ☐

Name: ____________________

Date: ____________________

Period: ____________________

21. What 3 things are required to generate a voltage:

21A.

21B.

21C.

22. One cycle contains two______, one positive, and one negative.

22.

23. The number of complete AC cycles occuring in one second is referred to as the AC__________.

23.

24. Find the period of an AC wave if the frequency is 15MHz.

Show work

24.

25. Find the wavelength of an AC wave if its frequency is 15MHz.

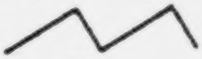
Show work

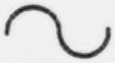
25.

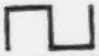
26. When comparing an AC voltage to a DC voltage, the equivalent AC value is called the ______ value.

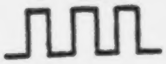
26.

27. Identify the following wave forms.

A. 

B. 

C. 

D. 

27A.

27B.

27C.

27D.

28. Label the following frequency bands.

A. 20 - 20,000Hz

B. 30kHz - 30GHz

C. 3×10^{19}Hz - 5×10^{20}Hz

28A.

28B.

28C.

Name: ____________________

Date: ____________________

Period: ____________________

29. Indicate the FCC "allocated use" for each of the radio frequency bands listed below.

A. 535kHz - 1605kHz

B. 174MHz - 216MHz

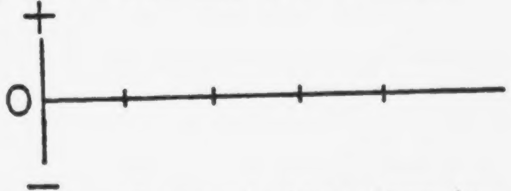
C. 88MHz - 108MHz

29A. ☐

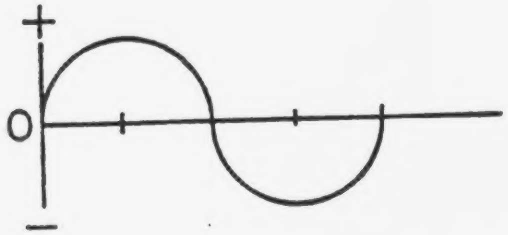
29B. ☐

29C. ☐

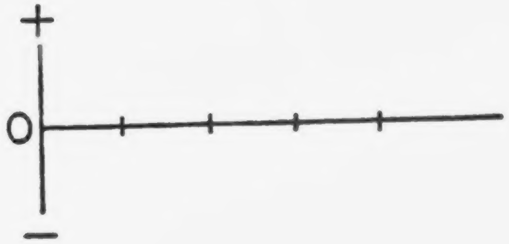
30. On the axis below, draw one cycle of an AC sine wave. Label the 0°, 90°, 180° 270° and 360° points.



31. Utilizing the AC wave below, draw in, and label, arrows to indicate how you would measure A) the peak amplitude, and B) the peak to peak amplitude.



32. Draw a sketch of two AC sine waves that are 90° out-of-phase.



Name: ____________________

Date: ____________________

Period: ____________________

SCORE:

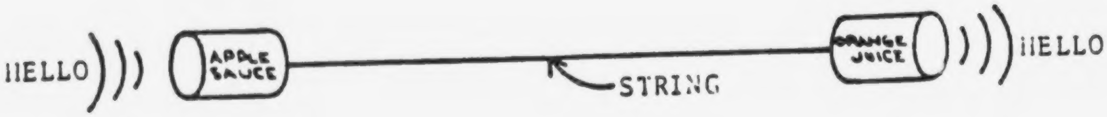
GRADE:

WORKSHEET

QUEST ACTIVITY

"UNIT 9"

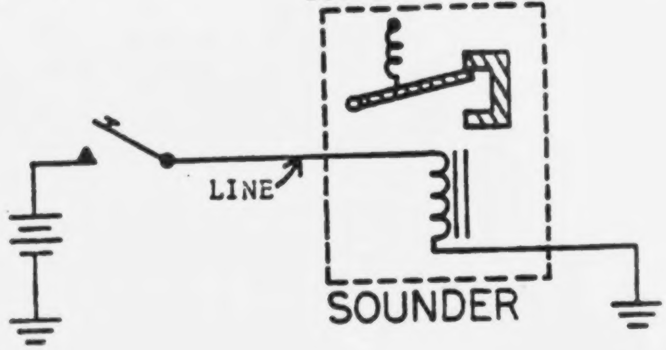
Communication plays a vital role in our existance. The systems developed to transmit information from person to person are consistently being improved, modified, or replaced with a more efficient process. Modern day communication systems employ techniques such as radio wave, microwave, and laser-light beam transmisssion. Below is the beginning of a chronolog of communication systems which you are to complete and document. Follow the examples given below and include a sketch or a block diagram of each system.



A

System and Inventor(s):	Can and string communication system invented 1850 by Tommy Primative and Kathy Can (Ha Ha)
Basic Operation:	Stretch string taut, then speaking into one can will cause sound to be reproduced in the receiving can
Transmitting Devices:	Human voice and can
Message Carrier:	String
Receiving Device:	Human ear and can
Decoding System:	Not necessary as long as languages are similar

B



System and Inventor(s):	Telegraph system patented 1843 by Samuel Morse

Name: ____________________

Date: ____________________

Period: ____________________

Basic Operation:	Hand-operated switch (key) controls pulses of current (dots and dashes) which are assigned alphanumeric meaning
Transmitting Device:	Telegraph key
Message Carrier:	Wire
Receiving Device:	Telegraph Sounder
Decoding System:	Electrical pulses converted to sound waves and received by human ear and translated by brain applying Morse Code knowledge

C (Telephone System)

D (Phonograph System)

E (Radio System)

F (Television System)

G (Other see instructor)

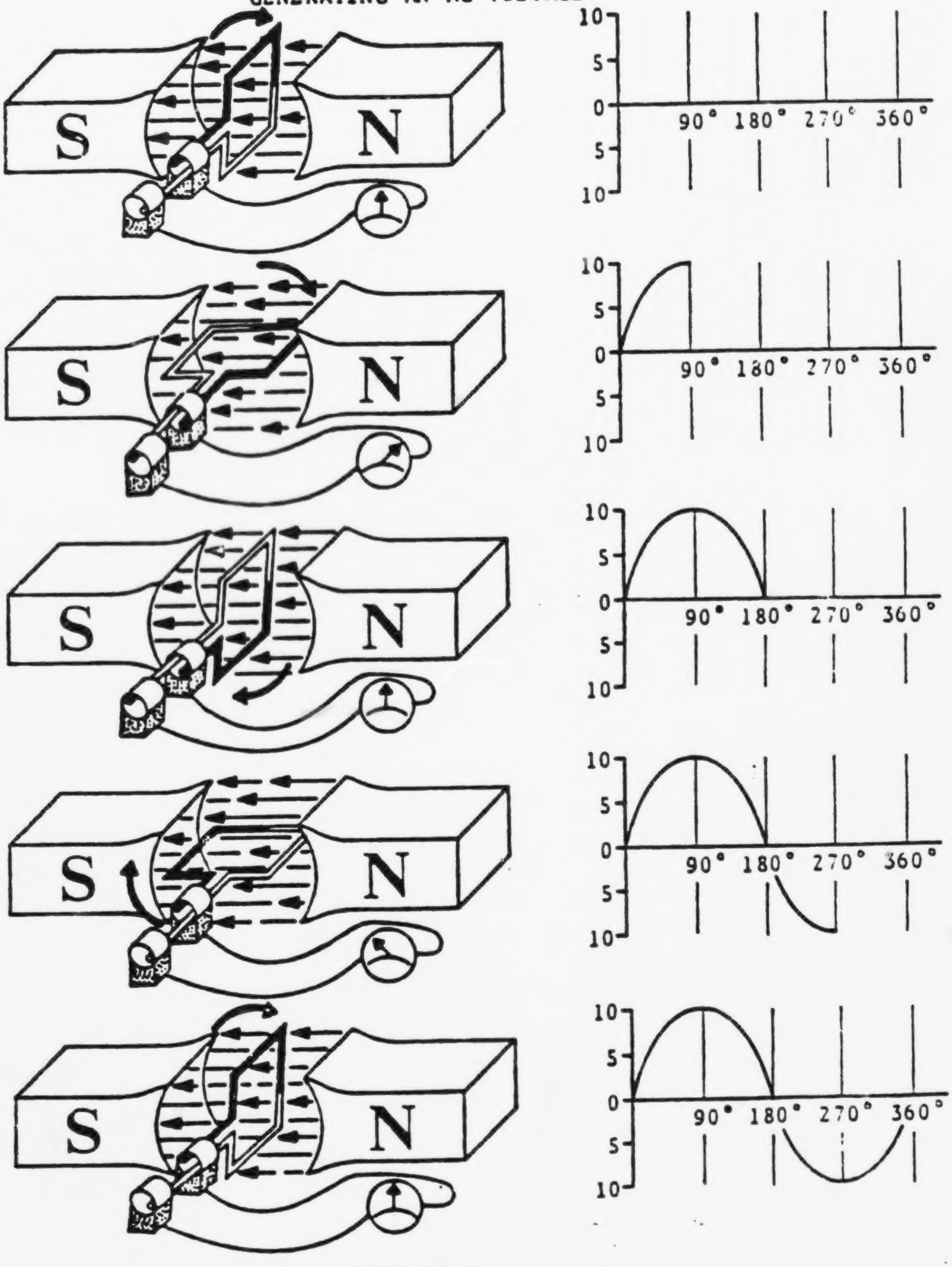
Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

GENERATING AN AC VOLTAGE


S
N
10
5
0
5
10
90°
180°
270°
360°

Name: ______________________

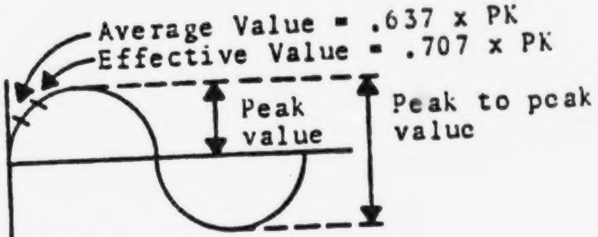
Date: ______________________

Period: ______________________

INFORMATIONAL HANDOUT

AC FORMULAS

AC VALUES:


Average Value = .637 x PK
Effective Value = .707 x PK
Peak value
Peak to peak value

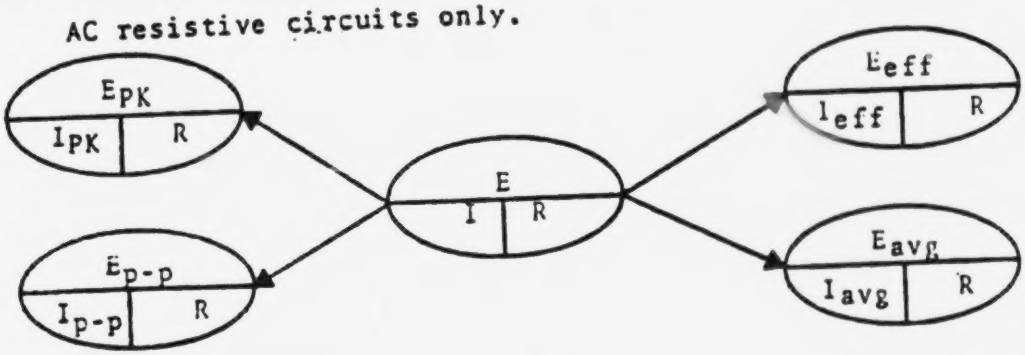
CONVERSION FORMULAS:

Formulas apply equally for AC voltage or current.

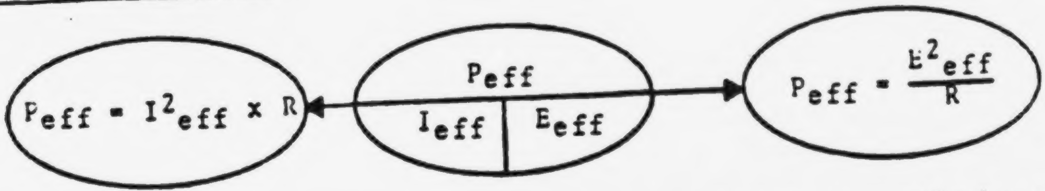
Peak-to-Peak = 2 x peak
Peak = 1/2 x peak-to-peak
Average = .637 x peak
Effective or RMS = .707 x peak
Peak = 1.414 x effective

OHM'S LAW FORMULAS:

AC resistive circuits only.


E_{PK}
I_{PK}
R
E_{eff}
I_{eff}
R
E
I
R
E_{p-p}
I_{p-p}
R
E_{avg}
I_{avg}
R

WATT'S LAW FORMULAS:


$P_{eff} = I^2_{eff} \times R$
P_{eff}
I_{eff}
E_{eff}
$P_{eff} = \frac{E^2_{eff}}{R}$

NOTICE: To apply either Ohm's law or Watt's Law correctly be sure that the method used for measuring AC voltage and current is similar. That is, if voltage is measured as a peak value, the current must also be measured as a peak value.

Name: ____________

Date: ____________

Period: ____________

PERIOD AND WAVELENGTH:

Period $T = \frac{1}{f}$

WHERE

T = period in seconds

f = frequency in Hz

Wavelength $= \frac{300,000,000}{f}$

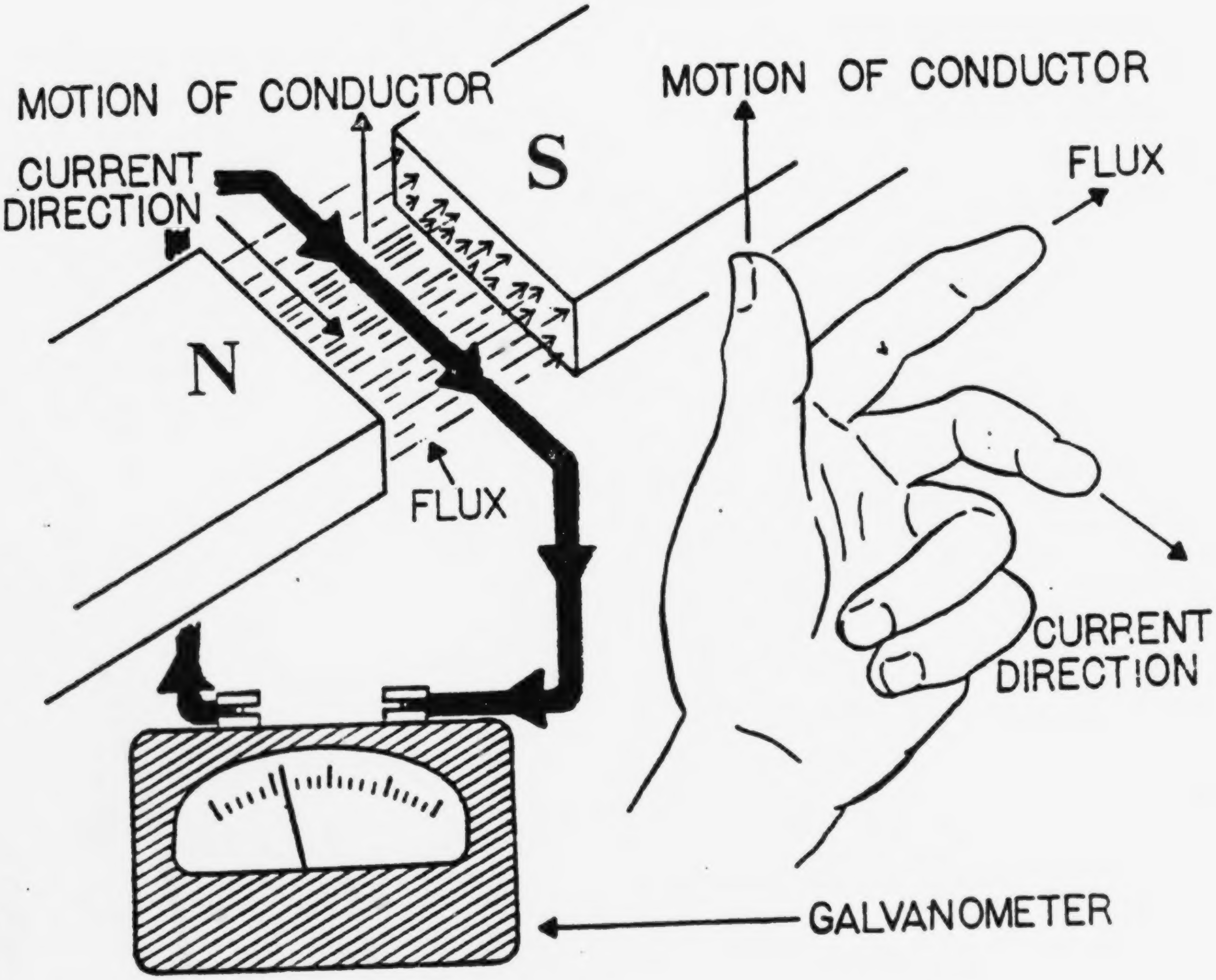
WHERE

= wavelength in meters

300,000,000 = speed of ligh in meters/sec

f = frequency in Hz.

LEFT-HAND RULE


MOTION OF CONDUCTOR
MOTION OF CONDUCTOR
CURRENT DIRECTION
S
FLUX
N
FLUX
CURRENT DIRECTION
GALVANOMETER

Name: ______________

Date: ______________

Period: ______________

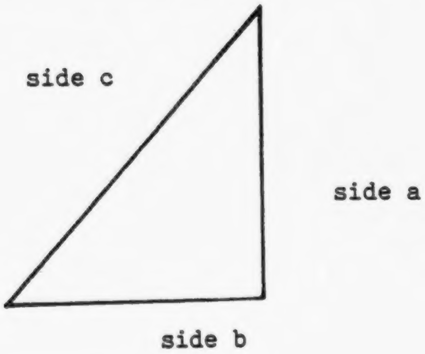
INFORMATIONAL HANDOUT

ELECTROMAGNETIC SPECTRUM

FREQUENCY	NAME	APPLICATIONS
0Hz	Steady direct current or voltage	DC motors, solenoids, relays, electrode voltages for tubes and transistors
20Hz - 20,000Hz	Audio frequencies	60Hz power, ac motors, audio amplifiers, microphones, loudspeakers, phonographs, tape recorders, high-fidelity equipment, public address systems, and intercoms
16kHz-30kHz	Ultrasonic frequencies or very low radio frequencies	Sound waves for ultrasonic cleaning, vibration testing, thickness gauging, flow detection, and sonar; electromagnetic waves for induction heating
30kHz-30GHz	Radio frequencies	Radio communications and broadcasting, including television, radio navigation, radio astronomy, industrial, medical, scientific and military radio
300GHz-430THz	Infared light rays	Heating, infared photography
430THz-1000THz	Visible light rays	Color, illumination, photography
1×10^{15}Hz-6×10^{16}Hz	Ultraviolet rays	Sterilizing, deodorizing, medical
3×10^{19}Hz-5×10^{20}Hz	X-rays	Thickness gauges, inspection, medical
5×10^{20}Hz-8×10^{21}Hz	Cosmic rays	Exist in outer space; can penetrate 70 m of water or 1 m of lead

A.C. MATH PROBLEMS

Name ____________________ Date ____________ Per. _____

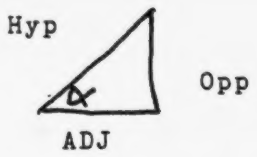


1. Name the sides of the triangle
   - Side a ________________
   - Side b ________________
   - Side c ________________

2. Formulae use letter use name
   - a. sin = __________ or __________
   - b. cos = __________ or __________
   - c. tan = __________ or __________

3. Work the following problems. (Show all work)
   - a. opp. = 3 adj = 4 Hyp = _________ $\angle\alpha$ = ______________
   - b. opp = 6 adj = 8 Hyp = _________ $\angle\alpha$ = ______________
   - c. opp = 30k adj = 25k Hyp = _________ $\angle\alpha$ = ______________
   - d. Hyp = 10k adj = 5k Opp = _________ $\angle\alpha$ = ______________
   - e. Opp = 5x Hyp = 7.5v Adj = _________ $\angle\alpha$ = ______________
   - f. $\angle\alpha$ = 30 Adj = 10v Opp = _________ Hyp = ______________
   - g. Opp = 15v Adj = 25v $\angle\alpha$ = _________ Hyp = ______________
   - h. Adj = 50k Hyp = 35k $\angle\alpha$ = _________ Opp = ______________

A.C. MATH PROBLEMS #2 Name ______________________________



1. Given: Opp 30 Ω ADJ. 40 Ω

Solve for -

a. Hyp
b. α
c. tan α
d. Cos α
e. Sin α

1a. ______________________
b. ______________________
c. ______________________
d. ______________________
e. ______________________

2. Given: 30 Adj. 3k

a. α
b. Adj.

2a. ______________________
b. ______________________

3. Given: Opp lokΩ, Hyp .01MΩ
Solve for
a. α
b. Adj.

3a. ______________________
b. ______________________

4. Given: α 67°, Hyp 18k Ω
Solve for
a. Adj.
b. Opp

4a. ______________________
b. ______________________

5. Given: Hyp 37k, Opp 15k
Solve for
a. Adj
b. α

5a. ______________________
b. ______________________

Date ____________ Per _____

1. What is the AM band of frequencies? ____________________

2. What is the AM bandwidth? ____________________

3. What is the FM band of frequencies? ____________________

4. What is the bandwidth of your FM radio? ____________________

5. List the band of frequencies and the bandwidth for the following T.V. stations:
    a. Channel 3 ____________________
    b. BW ____________________
    c. Channel 6 ____________________
    d. BW ____________________
    e. Channel 10 ____________________
    f. BW ____________________
    g. Channel 13 ____________________
    h. BW ____________________
    i. UHF band ____________________
    j. UHF bandwidth BW ____________________
    k VHF band ____________________
    l. VHF bandwith ____________________
    m. microwave band ____________________

6. List frequencies for the following:
    a. infrared ____________________
    b. visible light ____________________
    c. ultraviolet ____________________
    d. x-ray ____________________
    e. gamma rays ____________________

7. Solve for the period of the following frequencies:
    a. the line frequency ________________
    b. FM 102 ________________
    c. AM 1530 ________________
    d. infra red ________________

8. Solve for the wavelength of the following frequencies:
    a. the line frequency in meters ______________
    b. the line frequency in feet ______________
    c. FM 102 in meters ______________

Lab. Exp. # ____

Name ______________ Per _____

Date ___________

Determine the following values using the information you have learned about solving right triangles. Be sure to include a diagram, label all values, show all work. Be careful. Work neatly, please.

A. The height of the backwall of the room is ________________________.

B. The Height of the flagpole in front of the school is ____________.

C. The peak of the roof on the highest building on the H. Johnson-West campus is ____________.

Name ______________________________

Date ________________

QUEST ACTIVITY - AC FUNDAMENTALS

Written Report

I. System ______________________________

II. Inventor/Inventors ______________________________

III. Date ________________

IV. Basic Operation

V. Transmitting Devices

VI. Message Carrier

VII. Receiving Device

VIII. Decoding System

TEST A

Name ____________________________

Directions:
Do the following problems.

1. Draw one cycle of a 5 volt AC 60 Hz current giving the proper time base. (Use 5 V peak in your diagram).

2. Define the following:
   a. period of a sine wave

   b. cycle of a sine wave

   c. alternation of a sine wave

   d. megaHertz

   e. kiloHertz

3. What is the wavelength of the following frequencies?
   a. 10 Hz

   b. 60 z

   c. 30 megaHertz

TEST A - continued

4. Find the peak voltage for the following effective voltages:
   a. 100v
   b. 6v
   c. 80v
   d. 3.2v
   e. 5.6v

5. Find the effective voltage for the following peak voltages.
   a. 45v
   b. 200v
   c. 7.5v
   d. 110v
   e. 3.2v

6. Draw a sine wave for alternating current and indicate the following:
   a. peak voltage
   b. peak to peak voltage
   c. average voltage
   d. effective voltage

Yes No Did you consider this a useful package? (Circle choice)

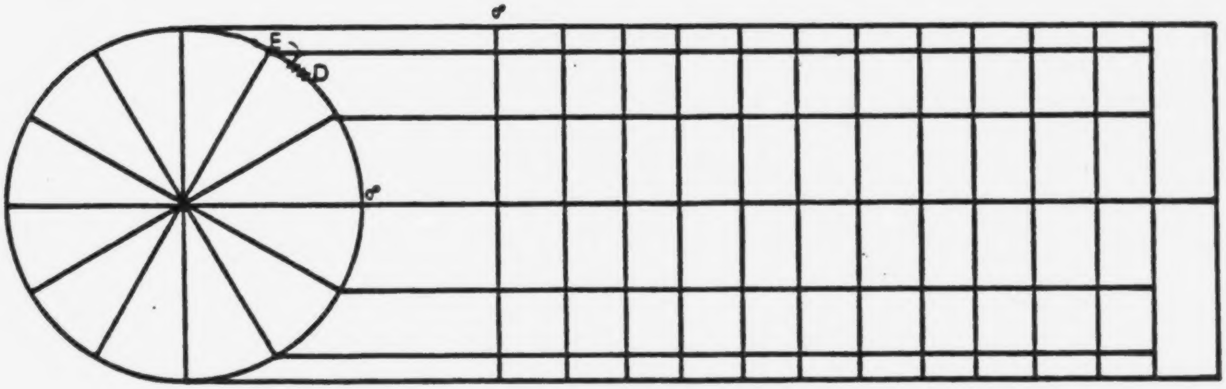
Name ______________________

Test B

Directions

Do the following problems.

1.



a. project sine wave onto graph at the right of the circle, moving in a counter-clockwise direction, starting from 0°.

b. At what degrees do the maximum voltages occur?

c. At what degrees do the minimum voltages occur?

d. Approximately what value does point D represent?

c. Approximately what value does point E represent?

Test B, continued

2. Write a definition for each of the following terms:

   a. period

   b. Hertz

   c. peak to peak value

   d. alternation

   e. frequency

3. Compute the period of the following frequencies:

   a. 100 Hz

   b. 10 Hz

   c. 10 kHz

Test B, continued

4. Compute the wavelength of the following frequencies:

   a. 10 kHz

   b. .3 Hz

   c. 186 kHz

5. Find the effective voltages for the following peak voltages:

   a. 3.2 v

   b. 110 v

   c. 7.5 v

   d. 200 v

   e. 45 v

Yes No Did you consider this a useful package? (Circle your choice)

ELECTRONICS A

QUIZ #8

For questions 1-4, use Fig #1. Each point noted in the figure represents a degree point on the Sin wave.

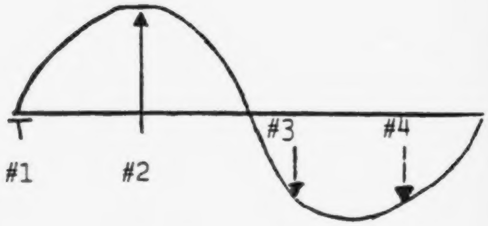


Fig #1

1. Point #1 = ?°
   A. 0 B. 45 C. 90 D. 180

2. Point #2 = ?°
   A. 0 B. 45 C. 90 D. 180

3. Point #3 = ?°
   A. 45 B. 180 C. 225 D. 270

4. Point #4 = ?°
   A. 45 B. 135 C. 225 D. 315

For questions 5-15, use the representative triangle in Fig #2

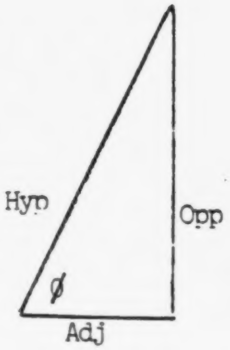


Fig #2

5. Opp =17; Adj = 31; Hyp = ?
   A. .548 B. 35.5 C. 10.98 D. 1250

6. Opp = 32K/ Adj = 27K; ∠ø = ?°
   A. 1.1852 B. 40.15 C. 41.86 D. 49.84

7. Opp = 2K; Adj = 3.7K; Tan ∠ø = ?
   A. .54 B. 28.39 C. 1.85 D. 61.61

8. ∠ø = 60°; Opp = 3.46K; Adj = ? K
   A. 2 B. 4 C. 6 D. 8

9. ∠ø = 45°; Adj = 7K; Opp = ? K
   A. 4 B. 5 C. 6 D. 7

10. Opp = 67mi; Adj = 96mi; Hyp = ?
    A. .698 B. 39.46 C. 117 D. 163

11. Opp = 367; Hyp = 675; Sin ∠ø = ?
    A. .5437 B. 1.8392 C. 70.68 D. 61.46

12. Opp = 30; Hyp = 50; ∠ø = ?°
    A. .6 B. 1.667 C. 36.86 D. 59

13. Adj = 6.2K; Hyp = 9.6K; Cos ∠ø = ?
    A. .6458 B. 1.5484 C. 49.77 D. 57.14

14. Adj = 875; Hyp = 1250; ∠ø = ?°
    A. .7 B. 1.4286 C. 45.57 D. 55

15. ∠ø = 30°; Hyp = 165; Opp = ?
    A. .5 B. 82.5 C. 60 D. 330

Test Number____

LIII-U9

UNIT EXAM

AC FUNDAMENTALS

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question- there is only one correct answer for each question.

1. Moving a piece of wire through a magnetic field will induce a voltage between the ends of the wire. (T-F)

2. If the speed at which a wire cuts the magnetic field is increased, the voltage generated will also be increased. (T-F)

3. You should expect the output voltage of an AC generator to look like a rectangular wave when plotted on graph paper. (T-F)

4. The type of electricity supplied to our homes is DC. (T-F)

5. Radio signals are considered AC type electricity. (T-F)

6. A radio uses both AC and DC type electricity in its operation. (T-F)

7. DC generators and AC generators work by the same electrical principle· electromagnetic induction. (T-F)

8. In the left hand rule for generators, the thumb points in the direction of the magnetic field. (T-F)

9. 90 degrees and 270 degrees are the only maximum points on the AC wave. (T-F)

10. An alternation and a half cycle are the same thing. (T-F)

11. One cycle contains 370 degrees. (T-F)

12. The higher the frequency, the closer together the sine waves will appear on the screen of an oscilloscope. (T-F)

13. The period of a DC wave is measured in seconds. (T-F)

14. In an AC resistive circuit, current and voltage are "in phase." (T-F)

15. If two AC waves start and end at the same place on an oscilliscope screen, they are out of phase. (T-F)

16. A factor which does not affect the output voltage of an alternator is (A) the speed of the loop. (B) the number of turns on the loop. (C) the strength of the magnetic field. (D) the size of the slip rings.

17. During one cycle, the peak voltage occurs
(A) five times. (B) twice. (C) once. (D) four times.

18. A cycle is made up of two parts called
(A) peak voltages. (B) loops. (C) frequencies. (D) alternations.

19. The number of cycles generated in a second is called
(A) an alternation. (B) the sine curve. (C) the frequency. (D) an alternating current.

20. Unless otherwise stated, AC meters read the
(A) effective (RMS) values. (B) average values. (C) peak values. (D) 3.1416 x peak values.

21. When a graph is drawn of an AC voltage the shape of the resulting curve is called the
(A) phase. (B) waveform. (C) frequency. (D) none of the above.

22. A quarter cycle of an AC wave is the equivalent of
(A) 45° (B) 90° (C) 180° (D) 360°

23. Two AC voltages that are always "in phase" must have the same:
(A) current value. (B) voltage value. (C) frequency. (D) none of the above.

24. The average value of an AC sine wave voltage is solved by using the formula
(A) .707 x peak (B) .637 x peak (C) 1.414 x peak (D) none of the above.

25. An alternating current wave changes in
(A) direction only. (B) value only. (C) both value and direction (D) frequency and value but not direction.

26. Alternating current is used as
(A) a source of electrical power and as a means of carrying information or intelligence. (B) a source of power only. (C) a means of carrying information only. (D) an AC signal only.

27. A device which utilizes electromagnetic induction as a means of producing an AC voltage is called:
(A) an oscillator. (B) an induction motor. (C) a battery (D) an AC generator.

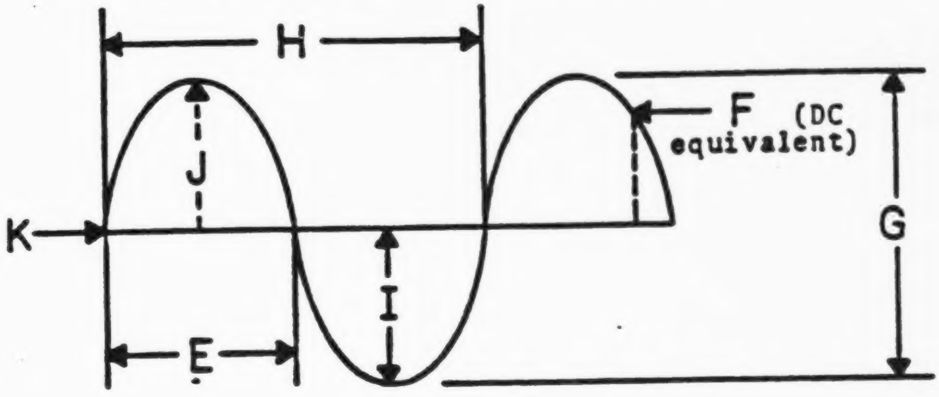
28. The essential elements which are needed to form a basic AC generator are
(A) slip-rings, brushes, and a magnetic field. (B) an armature, slip-rings, and brushes. (C) slip-rings and brushes. (D) an armature, slip-rings, brushes, and a magnetic field.

29. One cycle of an AC sine wave contains
(A) two positive alternations and one negative alternation. (B) two negative alternations. (C) only one alternation. (D) one positive alternation and one negative alternation.

30. The maximum value which occurs during an alternation of a sine wave is called the
(A) peak point. (B) peak value. (C) peak-to-peak value. (D) positive peak-to-peak value.

31. Which of the waveforms listed below is not a nonsinusoidal wave? (A) sawtooth wave. (B) triangular wave. (C) sine wave. (D) square wave.

Match the lettered parts of the graph to their appropriate terms. Write the corresponding letter on your answer sheet.



32. Peak-to-peak _____.

33. Cycle _____.

34. Alternation _____.

35. Maximum negative amplitude _____.

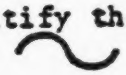
36. Maximum positive amplitude _____.

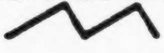
37. Zero emf _____.

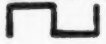
38. Effective value _____.

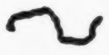
39. A frequency of 90kHz is located within which band of frequencies? (A) audio band. (B) ultra sonic band. (C) visible light band. (D) radio frequency band.

40. Identify the square wave in the drawings below:

(A) 

(B) 

(C) 

(D) 

41. A voltage sine wave with a peak value of 200 volts will have an average value of
(A) 314.5 volts. (B) 282.8 volts. (C) 127.4 volts. (D) 141.4 volts

42. An AC current with a peak value of 16 amperes would have an effective value of
(A) 10.18 amperes EFF. (B) 11.3 amperes EFF. (C) 22.63 amperes EFF.
(D) 25.16 amperes EFF.

43. An AC voltage has a peak value of 10 volts, hence its peak-to-peak value is
(A) 10 volts p-p. (B) 7.07 volts p-p. (C) 6.37 volts p-p. (D) 20 volts p-p.

44. If you measured an AC voltage with the shop meter that read 10V p-p, what would the peak value be?
(A) $5V_{PK}$. (B) $20V_{PK}$. (C) $10V_{PK}$. (D) $7.07V_{PK}$.

45. Given a value of $40V_{RMS}$, what is the effective AC value?
(A) $20V_{EFF}$. (B) $80V_{EFF}$. (C) $28.28V_{EFF}$. (D) $40V_{EFF}$.

AC FUNDAMENTALS

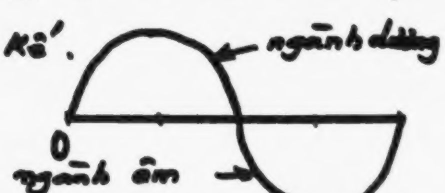
Alternating current : điện xoay chiều.

âm điện tử chạy trước tiên theo một chiều trực tiếp, dừng lại, và chạy theo chiều ngược lại.

Cường độ chạy bắt đầu tại zero, tăng đến mức tối đa dương rồi giảm đến zero, sau đó tăng đến mức tối đa âm và lại giảm xuống về zero. Điện xoay chiều được miêu tả bằng một sóng hình sine
viết tắt là : AC.

Depicted as : miêu tả bằng, miêu tả như.

alternation : ngành dương hoặc âm của một chu kỳ sóng hình sine. (hay là nửa sóng AC hoặc nửa chu kỳ) bắt đầu từ 0° và kết thúc tại điểm 0° kế.



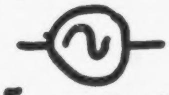
có nghĩa là ngành dương từ 0° đến 180°. Ngành âm từ 180° đến 360°.

1. ACF

alternator = AC generator : máy phát điện xoay chiều.

một máy phát điện AC gồm 4 phần căn bản :

1. stator (magnetic field) phần ứng điện: nam châm. từ trường
2. rotor = loop . phần quay (lõi quay)
3. slip rings vòng góp điện
4. Brushes bàn chảy điện (là công tắc cọ sát với vòng góp điện)

Ký hiệu của máy phát điện AC là  viết tắt bằng chữ GEN.

DC generator : máy phát điện một chiều.

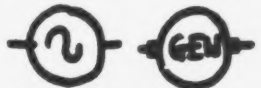
một máy phát điện DC gồm 4 phần căn bản.

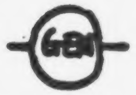
1. magnetic field
2. armature phần quay.

2.ACF

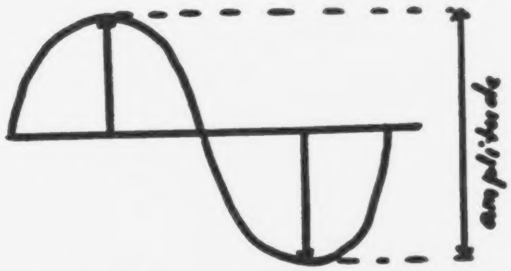
3. Commutator
cổ tiếp điện.
4. Brushes
bàn chảy điện (công tắc)

So sánh giữa AC và DC generator :
giống nhau: - magnetic field.
- Brushes

Khác nhau: - AC : slip rings ≠
DC : commutator.
- AC: rotor ≠
DC: armature.
- AC : 

≠
DC : 

Amplitude = vertical : biên độ
chiều cao



3. ACF

audio frequency = A.F : (Hạ tần). âm tần số
từ 20 Hz - 20 KHz

Radio frequency = R.F , (Cao Tần). vô tuyến tần
số từ 10 KHz - 300 GHz
($1 \text{ GHz} = 1 \times 10^9 \text{ Hz}$)

Average value : giá trị trung bình.
Average value = .637 x peak value.

Effective value = RMS : giá trị tác dụng :
RMS = Effective value =
.707 x peak value

$$\text{peak} = \frac{\text{peak to peak}}{2}$$

peak to peak = p-p :
tức là chiều cao của sóng
hình Sine được đếm từ
maximum positive đến
maximum Negative nhân với
trị số được chỉ trên hệ
Thống VOLTS/CM của oscilloscope
ở phía tay trái._

Muốn tìm peak value thì lấy peak to peak chia cho 2 hoặc đếm trên một ngành dương hoặc âm của Sine wave trên oscilloscope x trị số chỉ ở VOLTS/CM .

Khi có peak value ta có thể tìm average hoặc Effective value.

Band : băng tần.
AM radio band : từ 535KHz - 1605KHz
FM : từ 88MHz - 108MHz

distortion : sự biến dạng.
một sự thay đổi nhỏ vào hình sóng khi chuyển hướng ở biên độ, góc vị tướng hoặc tần số.

Electromagnetic induction : cảm kháng điện từ.

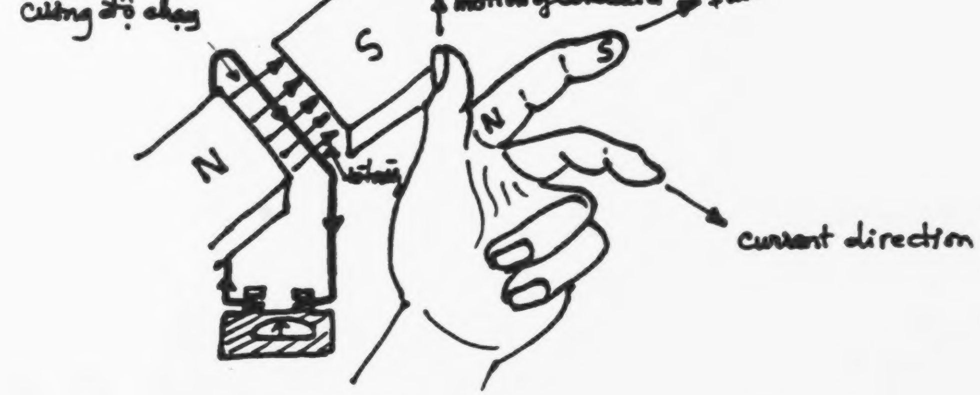
Federal Communication Commission : (FCC) : Sự qui định số lượng tần số quang phổ (frequency spectrum).

field winding : cuộn cảm kháng điện từ.
một bộ dây quấn trong máy phát điện mà nó hấp thụ điện thế DC để tạo ra điện từ trường.

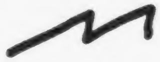
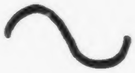
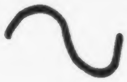
Harmonic : Họa tần.
từ tần số căn bản được nhân lên như 100 Hz là tần căn bản bậc 1.
100Hz x 2 = 200Hz là Họa tần 2.
100Hz x 3 = 300Hz là Họa tần 3.

5. ACF

Hertz = CPS :	chu kỳ trên giây. là đơn vị của tần số (frequency) 1 Hertz = 60 chu kỳ xảy ra trên 1 giây.
instantaneous value :	giá trị tức thời.
inverter :	bộ đảo điện từ DC biến thành AC.
Left hand Rule :	qui tắc bàn tay trái. phương pháp dùng bàn tay trái để xác định hướng đi của cường độ trong chất dẫn điện. * ngón tay cái chỉ hướng chuyển động của chất dẫn điện. * ngón tay trỏ chỉ hướng của từ trường từ Bắc đến nam (N - S) * Ngón tay giữa chỉ chiều của cường độ.


cường độ chạy
motion of conductor
flux
S
N
S
N
từ thông
current direction

G. ACF

nonsinusoidal	:	sóng khác dạng sine nonsinusoidal chỉ sóng vuông (⊓⊔). ...
Oscillator	:	đèn dao động. biến đổi năng lực DC thành năng lực AC.
Period	:	Thời gian T . $T = \frac{1}{f}$
Phase angle	:	góc vị tướng. Hệ số góc giữa cường độ và điện thế.
sawtooth wave	:	sóng răng cưa. 
Sine wave	=	Sinusoidal sóng hình sine 
Square wave	:	Sóng vuông.
waveform	:	hình sóng trên màn ảnh. như DC : AC : 
wavelength (λ) /lăm đa/	: :	chiều dài sóng

$$\lambda = \frac{\text{velocity} \leftarrow \text{vận tốc ánh sáng}}{\text{frequency} \leftarrow \text{tần số}}$$

$$\lambda = \frac{300{,}000{,}000}{f}$$

7. ACF

LIII-U9-11,-12,

交流电基礎 (AC FUNDAMENTALS)

技術語彙

alternative CURRENT : 交流电

alternation : 变换, 半週期变更

depict : 描写, 描出

wave : 波 .

cycle : 週期

alternater : 交流电发电机

stater : 定子

rotor : 旋轉子

slip rings : 滑动環

brush : 刷, 电刷

amplitude : 振幅、幅度 .

vertical : 垂直的.

armature : 电樞, 銜鐵

audio frequency : 音频, 声音频率 AF、

average value : 平均值 , AVG.

band . 波段, 频带, 區域 .

adjacent : 鄰近的.

encompasses : 包含, 圍繞

commutater : 换向器, 整流子, 交换机

ride on : 搭碰在---上 .

distortion : 畸变, 失真

expected : 希望的

deviation : 越軌, 脫離 .

phase : 相

effective value : 有效值

peak value : 巅值、峰值

root-mean-square value : 均方根值 、RMS.

electromagnetic induction : 电磁感应

spectrum：譜,光譜,频率譜.

field winding：磁场绕组 勵磁绕组

frequency：频率,(Hz)(f.)

generator：发电机 或

harmonic：諧波,諧音,諧波的,調和的.

hertz：赫兹 (Hz) (cps = cycle per sec.)

instantaneous value：瞬時值

inverter：反向变流机(由直流变成交流)

left hand rule：左手定則.

thumb：姆指.

first finger：食指

second finger：中指

nonsinusoidal：非正弦的.

oscillator：斷續器,振盪器(將DC能轉換為AC能).

peak-to-peak：正负峰间波动,最大电压波动.(p-p.)

LIII-U9-12,

peak value：巅值,峰值 (PK)

period：週期,一个完整的交流电週期 (T)(= $\frac{1}{\text{频率}}$)

angular：銳角,角的.

comparison：比較

phase angle：相角,相移角.

radio frequency：射频,无线电频率 (RF

infrared light：紅外线光

radiate：輻射.

sawtooth wave：鋸齒波.

sine wave：正弦波

sinusoidal：正弦的

square wave：矩形波,方波

duration：持續期间,在…继续的期间

waveform：波形

pattern：图型.

shape：型,像.

-23, -26, -27
LIII-49-14, -21, -22,

x-y axis : (X)水平-(Y)垂直軸

wavelength : 波长

allocated use : 分配使用位置.

basic operation : 基本操作

transmitting device : 发音装備.

massage carrier : 信號輸送

receiving device : 收接装備

decoding system : 譯碼系统

telephone : 电話

phonograph : 唱机. 电唱机

radio : 无线电收音机

television : 电視机

flux : 磁力线, 磁通量. 助焊劑. 通量

ultrasonic : 超音波, 超声波

visible : 可見的. 可以被看见的.

ultraviolet rays : 紫外线

cosmic rays : 宇宙(射)线.

high fidelity : 高保真度

intercoms = intercommunication system
内部通信装置

sonar : 声納(声波導航和测距系统

broadcasting : 廣播.

navigation : 導航. 航行.

astronomy : 天文学. 星学.

photography : 照像術

illumination : 发亮光

sterilizing : 消毒

deodorizing : 除味(氣味)

outer space : 外太空

penetrate : 貫穿, 穿透.

ultra = 超.

extremely : 特

ELECTRONIC CURRICULUM
VOCATIONAL TRAINING LESSON PLAN # ______ Circuit Protection Devices

Teaching Materials Source ______________________________
Chapter ______________, pages ______________
Lab Manual pages ______________
Additional Instructor Materials ______________________________

Main concepts student will learn:

1. To describe the major need for protective devices in circuits and/or equipment, and identify two typical types of protective devices which may be employed.
2. demonstrate the proper technique for wiring protective devices which may be employed.
3. troubleshoot a simple electrical circuit in order to identify the problem which may have caused a protective device to disable the circuit or equipment being investigated.

Length of Lesson

2 or 3 days

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Technical Vocabulary

see Glossary

Related General Vocabulary

Materials and Notes

1. Show students that our government does in fact look out for their safety and protection. Point out the function of the National Electrical Code and Underwriters' Laboratories. Demonstrate where the UL label can be located and why it is so vital in providing a margin of safety.
2. Demonstrate the technique of checking for continuity of a fuse. Refer to the devices resistance as a means to evaluate its quality.

Teaching Activity

1. When discussing types (fast, or slow blow) or kinds (plug, cartridge, knife-blade, etc.) of specific circuit protection devices it is advantageous to either pass them around or utilize an opaque/overhead projector to help familiarize students with their physical appearance. Inform students of the relationship between the physical size of the device and its electrical rating.
2. The topic of circuit breakers can be approached by first explaining the three basic types: thermal breakers, electro-magnetic breakers, and thermal-electromagnetic breakers. Define each variety and emphasize to students that they are typically used for feeder and branch-circuit protection in home electrical systems. Indicate that the ampere rating (size) of a breaker, always marked on the breaker lever, corresponds to the current carrying capacity of the wire being protected.
3. Remind students that it is extremely "dangerous" to tamper with a protective device. Give examples of what can occur if a fuse is intentionally by-passed or if a larger value fuse is utilized in a system.
4. An optional instructional topic on ground-fault circuit interrupts may be presented in this unit if the instructor feels it is appropriate.

Test Number _____

LII-U17

UNIT EXAM

IMPORTANT-
Record your answers on this exam paper only. When answering the matching problems, record the letter corresponding to your choice.

MATCHING:

1. A device used to change 117V AC to 6V or 12V AC.

2. A circuit which contains more than one path for current flow.

3. A material which allows free movement or flow of electrons.

4. A noise making device such as a bell or siren.

5. The "sensing" device in an alarm system.

6. A type of switch which is activated only as long as pressure is applied.

7. A circuit which contains only one path for current flow.

8. The "brain" or central unit of an alarm system.

9. A type of alarm sensor which projects an invisible field of electrical waves.

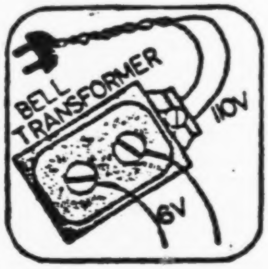
10. A circuit which contains both series and parallel sections.

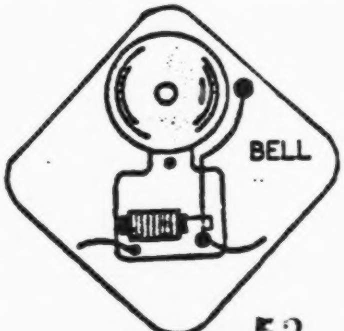
A. Series
B. Control unit
C. Conductor
D. Parallel
E. Signal device
F. Ultrasonic
G. Compound
H. Light beam
I. Toggle
J. Combination
K. Loop
L. Bell transformer
M. Detector
N. Push-button
O. Processor

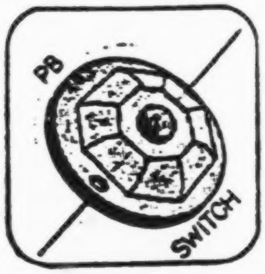
1. ☐
2. ☐
3. ☐
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐
9. ☐
10. ☐

---

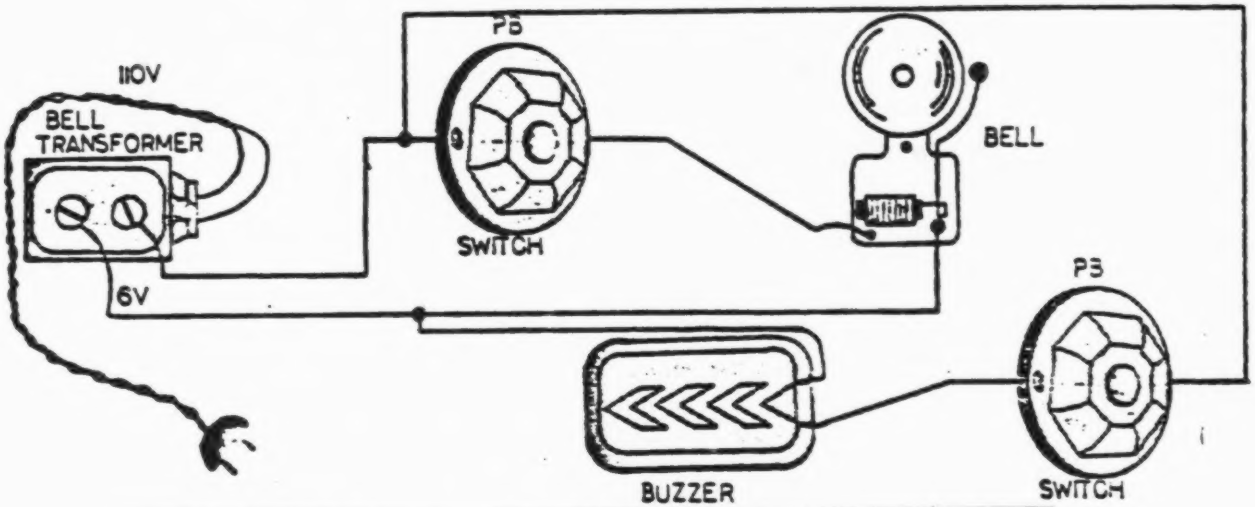
11. Connect the signal circuit components below into a series circuit.







12. Draw the schematic diagram which corresponds to the circuit pictured below.


PB
110V
BELL TRANSFORMER
SWITCH
BELL
6V
PB
BUZZER
SWITCH

Answer Box

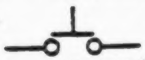
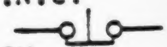
Low Voltage
Circuits

Name: ____________________

Date: ____________________

Period: ____________________

TECHNICAL GLOSSARY

ALARM CONTROL UNIT:	The "brain" or central unit in an alarm system. The control monitors the various detectors in the system and activates the alarm or signal device if the protection circuit is interrupted or violated. The control often contains an on/off switch, status indicators, time delays, power supplies, and stand by batteries.
ALARM DETECTOR:	The part of an alarm system which senses entry or movement in the protected area. The simplest detector is a switch; other common detectors are magnetic switches, pressure sensors, light beams, etc.
BELL TRANSFORMER:	A small transformer, with built-in overload and short protection, which will convert 117V to 6 or 12 volts for the operation of door bells, buzzers, or chimes.
COMBINATION CIRCUIT:	A circuit consisting of one or more series and parallel paths.
CONDUCTOR:	Any material through which electric current flows easily, such as a piece of copper wire.
LIGHT BEAM ALARM:	A common type of alarm or signaling circuit which will cause a signal device to sound if the light beam is broken.
PARALLEL CIRCUIT:	A circuit which provides two or more paths for current flow, sometimes referred to as a shunt or branch circuit.
PUSH-BUTTON SWITCH:	A spring loaded switch which is activated only as long as the push button is held in the down position. There are basically two types of P.B. switches - normally open and normally closed. Symbols: P.B.N.O.  P.B.N.C. 
SERIES CIRCUIT:	A circuit which has only one path for current flow. Series circuit components are connected in a line, one after the other.
SIGNAL DEVICE:	Generally a noise making device used to alert, notify, or gain your attention. Common signal devices are bells, buzzers, horns, or sirens.
ULTRASONIC ALARM:	A "motion detector" alarm which sets up an invisible field of electrical waves. If the wave pattern is disturbed or interrupted by movement of any kind, the alarm will be triggered.

SCORE:

GRADE:

Name: ____________________

Date: ____________________

Period: ____________________

WORKSHEET

VOCABULARY - SPELLING PUZZLE

Identify the correct spelling for the words listed below.

A.	(example) (exhample) (xample)	A.	EXAMPLE
1.	(cuntrol) (controll) (control)	1.	
2.	(circuit) (circut) (sircut)	2.	
3.	(beem) (beam) (beme)	3.	
4.	(allarm) (alarm) (elarm)	4.	
5.	(siginal) (signel) (signal)	5.	
6.	(switch) (swich) (swetch)	6.	
7.	(divice) (device) (devise)	7.	
8.	(ditectar) (detecter) (detector)	8.	
9.	(conducter) (kinducter) (conductor)	9.	
10.	(ceries) (series) (siries)	10.	
11.	(parallel) (parrallel) (parelel)	11.	
12.	(tranformer) (transformar) (transformer)	12.	
13.	(litc) (light) (liht)	13.	
14.	(combenation) (combinasion) (combination)	14.	
15.	(ultrasonic) (ultresonic) (ultrasonik)	15.	

SCORE:

GRADE:

Name: ____________________

Date: ____________________

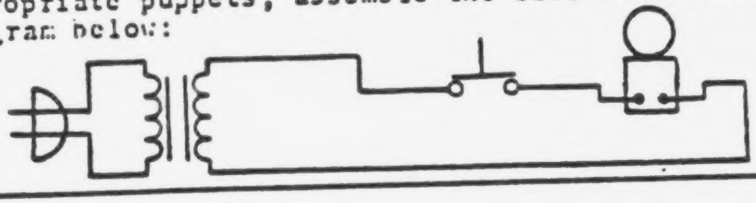
Period: ____________________

WORKSHEET

SERIES, PARALLEL, AND COMBINATION CIRCUIT WIRING OF SIGNAL DEVICES

Utilize the puppets provided on page 3 to construct the circuits described below. You will cut out and arrange the puppets to form series, parallel, and combination circuits. You must draw in interconnecting lines to represent the conductors. Be sure that each problem fulfills the four requirements for a complete electric circuit -- i.e. supply, control, load, and conductor.

1. Using the appropriate puppets, assemble the circuit described in the schematic diagram below:



2. Is the circuit in question "1" a series, parallel, or combination circuit?   2. ______

3. Design a buzzer circuit, which utilizes a 110V source, a bell transformer, and two push-button switches. Wire the circuit in such a way that pushing either switch will cause the buzzer to sound. Label the switches as a front door switch and a back door switch.

Name: ____________________

Date: ____________________

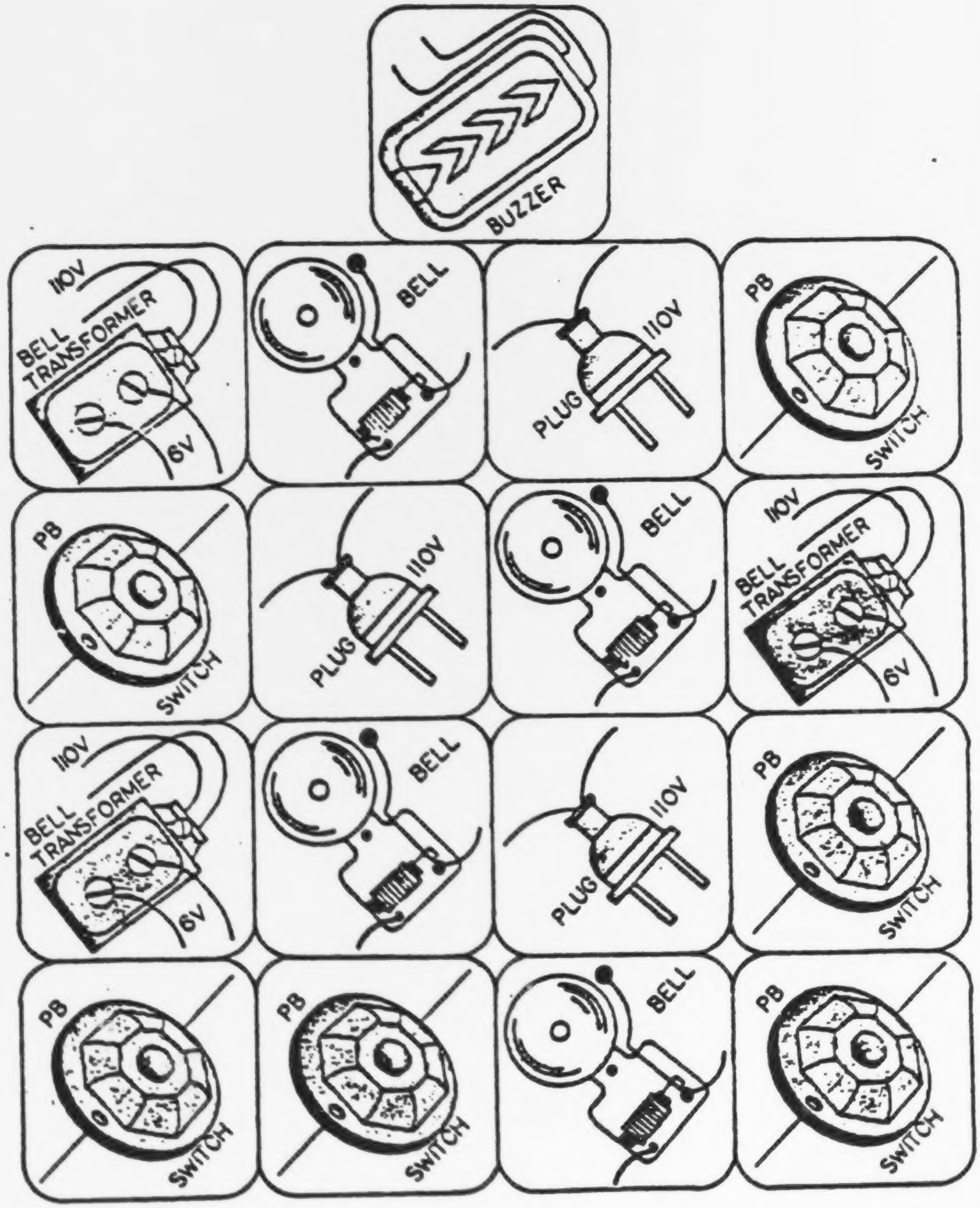
Period: ____________________

4. Would the switching circuit you built in question "3" be considered a series, parallel, or combination circuit?

4. ☐

5. Design a combination circuit having one series and one parallel switching branch. Use 3 switches, 2 bells, 1 bell transformer, and a 110V source. If any one of the switches is pressed, a bell must sound

Puppet Components


BUZZER
110V
BELL TRANSFORMER
6V
BELL
PLUG
110V
PB
SWITCH
PB
SWITCH
PLUG
110V
BELL
110V
BELL TRANSFORMER
6V
110V
BELL TRANSFORMER
6V
BELL
PLUG
110V
PB
SWITCH
PB
SWITCH
PB
SWITCH
BELL
PB
SWITCH

SCORE:

GRADE:

Name: ____________________

Date: ____________________

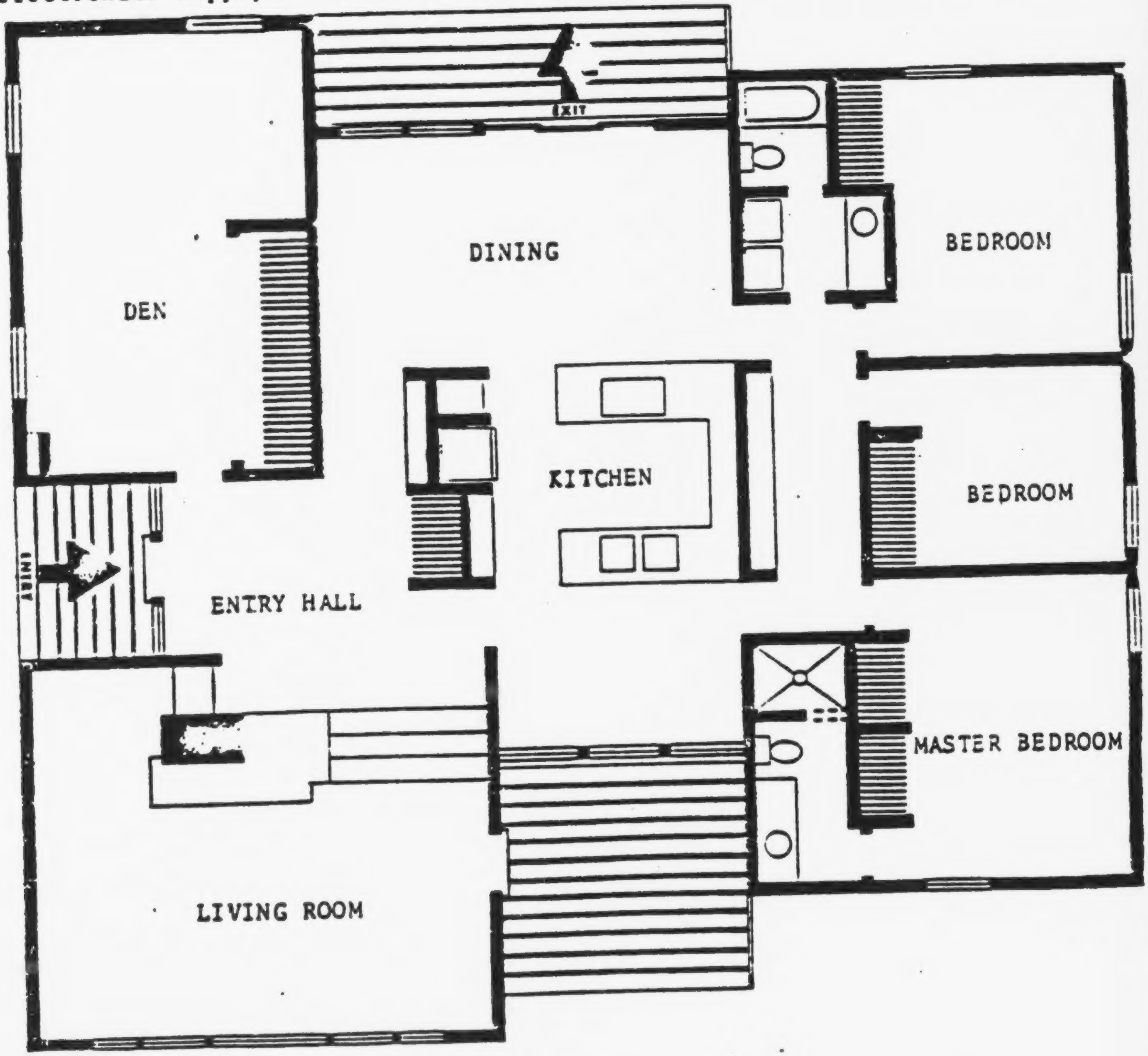
Period: ____________________

WORKSHEET

QUEST ACTIVITY

"UNIT 17"

Design a security alarm system for the house pictured below. You should include a control unit, various types of detectors, and one or more signal devices. Be imaginative, see if you can design a burglar proof system. Sketch in, and label the individual parts used in your security network, use single lines to represent the interconnecting wires needed to "tie" the various parts together. (Hint: use an alarm supply co. catalog or electronics supply house catalog to locate information on alarm products).


EXIT
DEN
DINING
BEDROOM
KITCHEN
BEDROOM
ENTRY
ENTRY HALL
MASTER BEDROOM
LIVING ROOM

Name: ____________________

Date: ____________________

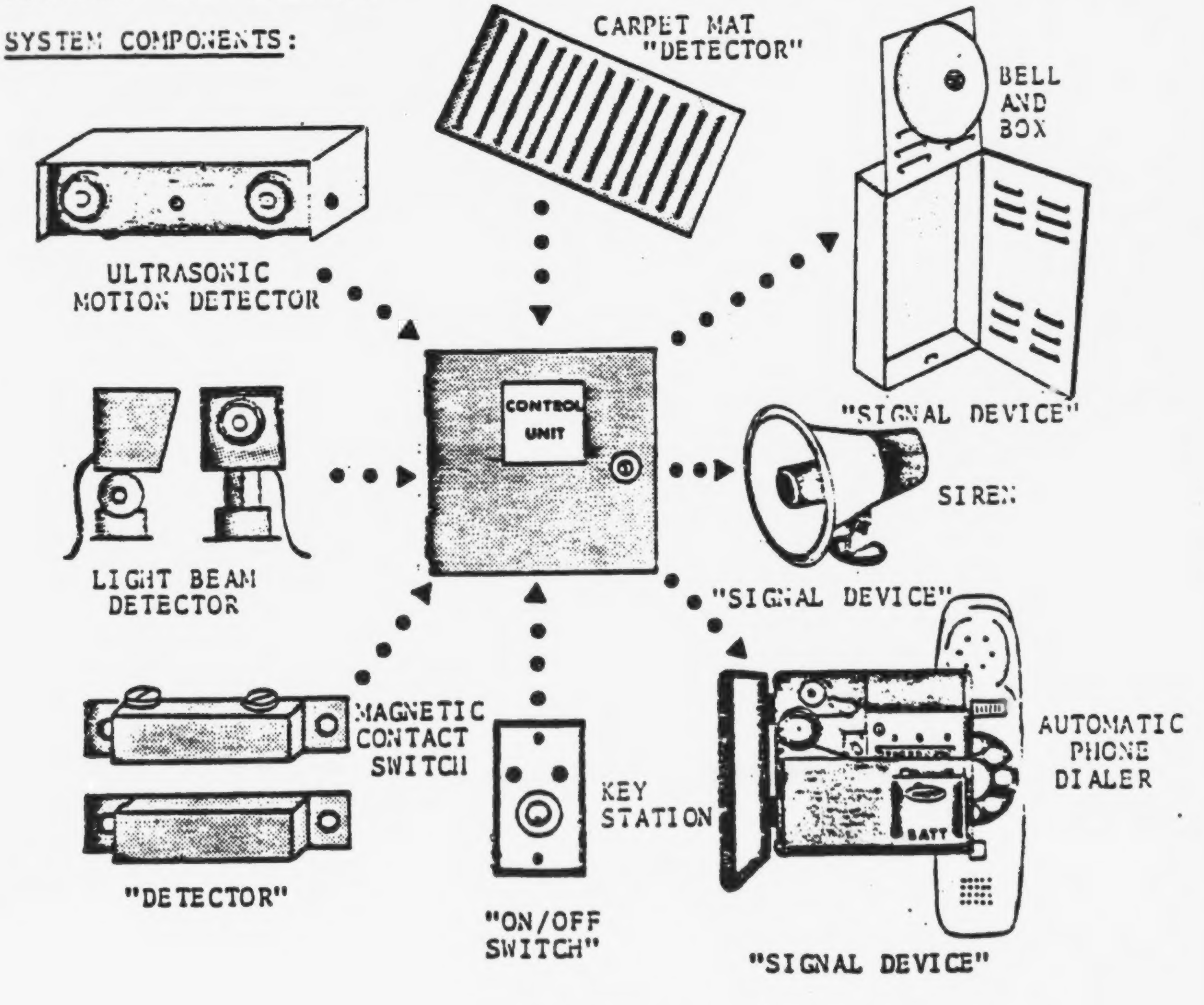
Period: ____________________

INFORMATIONAL HANDOUT

HOME SECURITY SYSTEMS

All burglar alarm systems have three common functions - detection, control, and signaling. The total system may be built into one box, or be made up of many separate pieces connected together with wire. "Detectors" are used to sense entry or movement within a protected area, and are basically switches or relays which operate by movement, pressure, or beam interruption. The "control unit" monitors the various detectors in the system, and triggers an alarm or signal device if the protection circuit sensor is interrupted or violated. The control unit also may contain on/off - power switches, test meters or status indicators, time delays, power supplies, stand by batteries, and terminals or lugs for wiring the system together. Finally, the signal device, usually a noise making bell or siren is used to alert or notify you, your neighbor, or the police, that a break-in has occurred.

SYSTEM COMPONENTS:

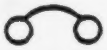
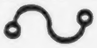

CARPET MAT "DETECTOR"
BELL AND BOX
ULTRASONIC MOTION DETECTOR
CONTROL UNIT
"SIGNAL DEVICE"
LIGHT BEAM DETECTOR
SIREN
"SIGNAL DEVICE"
MAGNETIC CONTACT SWITCH
KEY STATION
AUTOMATIC PHONE DIALER
BATT
"DETECTOR"
"ON/OFF SWITCH"
"SIGNAL DEVICE"

Name: ____________________

Date: ____________________

TECHNICAL GLOSSARY

Period: ____________________

CIRCUIT BREAKER:	A circuit protection device which is basically a thermal or electromagnetic switch, designed to break the current flow through a circuit in case of an overload or short. Circuit breakers have an advantage over fuses in that they can be easily reset many times. Symbol:  Rated in amperes.
CIRCUIT PROTECTION DEVICE:	A device used to protect a circuit from the potentially destructive effects of excessive current. The most common circuit protection devices are fuses and circuit breakers.
FUSE:	A device used to protect a circuit against excessive current flow. Fuses contain a calibrated "fuse link" which burns or vaporizes when too much current begins to flow through it. Symbol:  Rated in amperes.
FUSE LINK:	The thin strip of fusible metal built into a fuse, that will melt when the current flow through it exceeds a preset value. The higher the blow-out current rating, the larger the physical size of the fuse link. These links can take the form of hair thin wire or fairly thick strips of metal, and can be calibrated to one hundredths of an amp. (1/100).
OVERLOAD:	An unsafe circuit condition which occurs when a circuit carries more current than it can safely handle. Overloads can cause excessive heat, fire, or an electrical explosion.
RUNAWAY CURRENT:	A circuit condition such as a short, which allows the current in a circuit to increase uncontrollably past the safe limits of the circuit.
SHORT CIRCUIT:	An accidental circuit condition which results in a low resistance path between two points of the circuit (power supply terminals, line, etc.). A shorted circuit causes excessively high current flow and possible circuit damage.
TROUBLESHOOTING:	The process of logically locating and correcting improper operating conditions within an electronic circuit or system.

WORD POWER!

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - KNOW YOUR DEFINITIONS

Develop a short definition, using your own words, for the following terms.

1. FUSE:

2. OVERLOAD:

3. SHORT CIRCUIT:

4. TROUBLESHOOTING:

5. CIRCUIT BREAKER:

6. FUSE LINK:

SCORE:

GRADE:

Name: ____________________

Date: ____________________

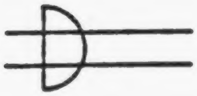
Period: ____________________

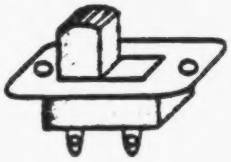
WORKSHEET

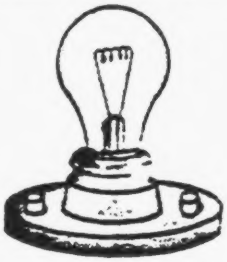
QUEST ACTIVITY

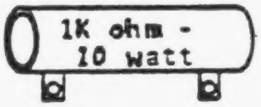
"UNIT 18"

1. Draw in the conductors and connect the circuit components below to form a series circuit. Add a fuse into the circuit so that it will act to protect the circuit against an overload or short.

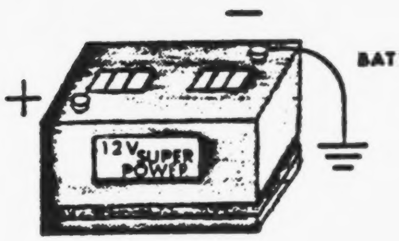




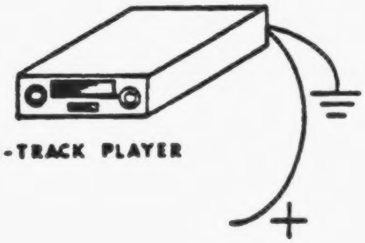




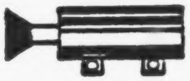
2. Connect the following automotive devices in parallel with the source, and in series with their controls. Add an in-line fuse to the tape deck branch, and a circuit breaker to the headlight branch.



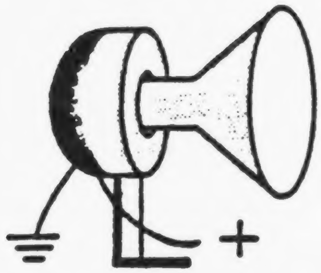
BATTERY



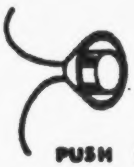
8-TRACK PLAYER



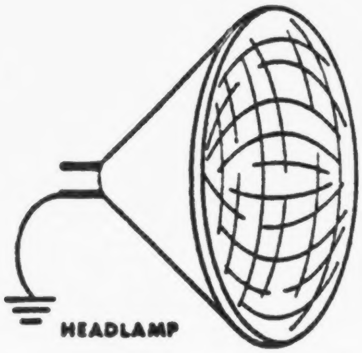
LIGHT SWITCH



HORN



PUSH BUTTON



HEADLAMP

Name: ____________________

Date: ____________________

Period: ____________________

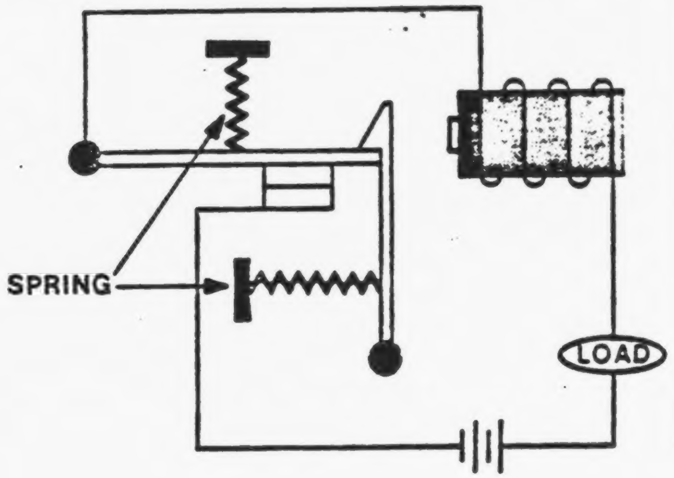
3. Draw a sketch of a fast acting (fast blow) and a slow acting (slow blow) fuse.

fast acting

slow acting

4. Explain the purpose or need for a slow acting fuse.

5. Explain how the circuit breaker pictured below operates.



Name: ____________________

Date: ____________________

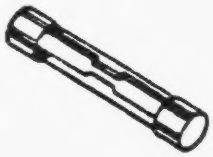
Period: ____________________

INFORMATIONAL HANDOUT

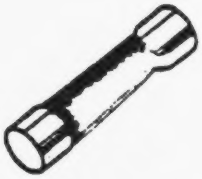
CIRCUIT PROTECTION DEVICES

Fuses or circuit breakers make up the major types of circuit protection devices in use today. These devices are used to protect against excessive current flow in a circuit and as such are rated in amperes. Fuses react to an abnormally high current by melting or vaporizing a special metal link which opens the circuit and halts the current flow. Circuit breakers contain either an electromagnet, or a bimetallic thermal strip, which opens a set of switch contacts when the breaker's rating is exceeded. Once the contacts open, the circuit current is stopped.

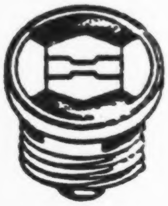
FUSE TYPES:



MINIATURE CARTRIDGE FUSE

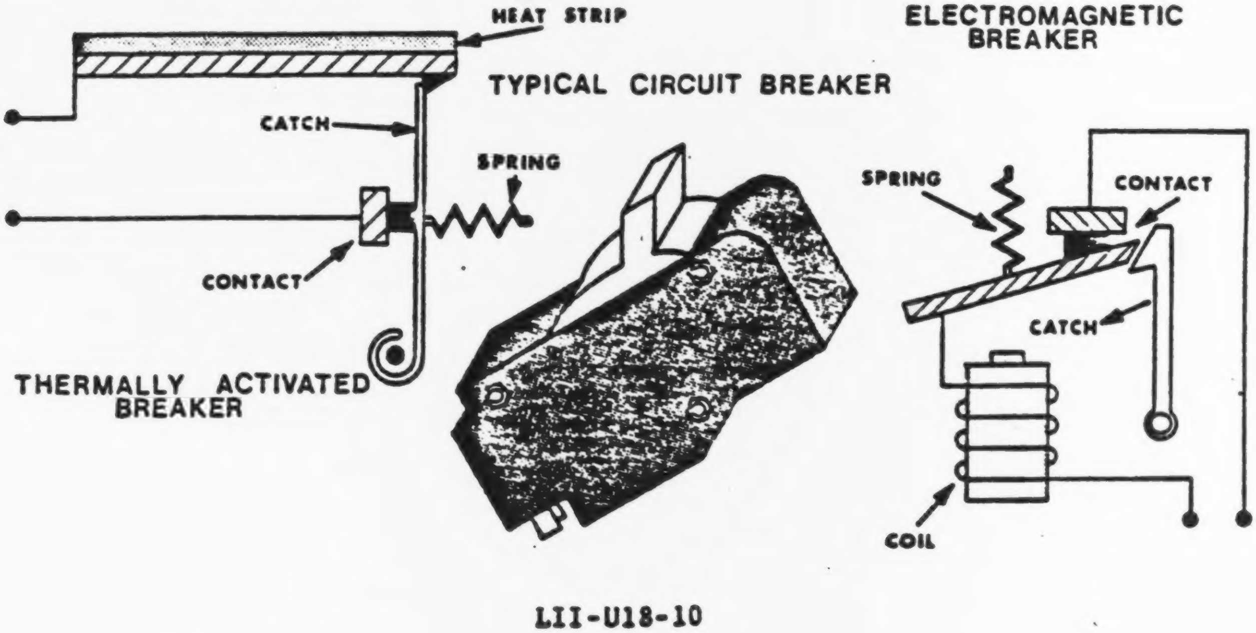


CARTRIDGE FUSE



PLUG FUSE

CIRCUIT BREAKER TYPES:



THERMALLY ACTIVATED BREAKER

TYPICAL CIRCUIT BREAKER

ELECTROMAGNETIC BREAKER

LII-U18-10

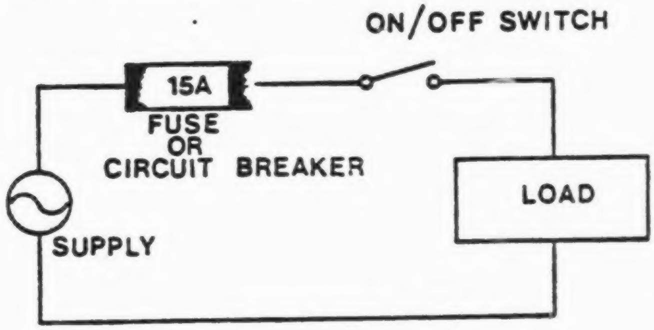
Name: ____________________

Date: ____________________

Period: ____________________

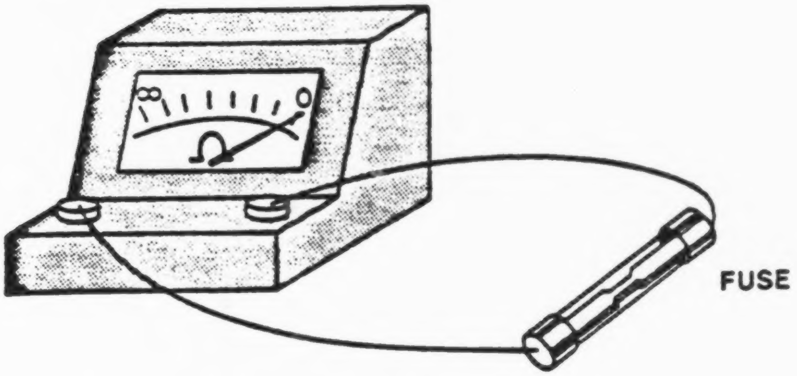
CIRCUIT CONNECTION:

To effectively protect a circuit from excessively high current flow, fuses and circuit breakers must be connected in series with the circuit they are protecting. A typical circuit application is shown below.


ON/OFF SWITCH
15A
FUSE OR CIRCUIT BREAKER
LOAD
SUPPLY

FUSE TESTING WITH AN OHMMETER:

Many times a quick visual inspection of a fuse's condition can be wrong. A fuse may look good when it is actually burnt out or defective. A sure fired way to check a fuse is to run a simple continuity test as illustrated below.



UNIT EXAM

CIRCUIT PROTECTION DEVICES

IMPORTANT:

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question. There is only one correct answer for each question.

1. A fuse or circuit breaker must be connected in series with the circuit it is protectin. (T - F)

2. When a fuse lin melts, or "blows" the electrical result is an open circuit. (T - F)

3. Miniature cartridge fuses are often used in automotive and instrument circuits. (T - F)

4. An overload can be safely prevented by increasing the size of the fuse protecting the circuit. (T - F)

5. Circuit breakers are used mainly on instruments and appliances. (T - F)

6. A "short circuit" causes an extremely high current to flow through the circuit. (T - F)

7. Circuit protection devices are rated according to the maximum current or amperage which can flow through them. (T - F)

8. Circuit breakers require occasional maintenance which involves manually tripping the device on and off. (T - F)

9. Circuit breakers contain several replacement fuse links, that can be switched into position by moving a lever. (T - F)

10. A 15 ampere fuse would be correct for use in a home outlet or lighting circuit. (T - F)

11. If the correct size fuse in a circuit continually blows or burns out, it probably indicates that you purchased a bad box of fuses or that you need a larger value fuse. (T - F)

12. When the current flowing through a circuit breaker is below the devices rated value, the breaker will trip. (T - F)

13. A circuit overload can be caused by:
a) using a fuse with a low amperage rateing b) connecting too many loads into the circuit c) may melt insulation and cause a short or fire d) either b or c.

14. A prolonged overload current:
a) can be avoided by using a higher amperage rating, b) will not affect the circuits operation c) may melt insulation and cause a short or fire d) usually will not trip a circuit breaker.

15. A short circuit:
a) is an extremely low resistance path which causes higher than normal current flow b) cannot occur in a circuit protected by the proper size fuse or circuit breaker c) can occur only in an AC circuit d) seldom causes the fuse or circuit breaker to open.

CIRCUIT PROTECTION

alarm : báo thức, báo động.
motion detector: máy dò hành động.
invisible field: từ trường vô hình.
electrical wave: sóng điện.
wave pattern: mẫu sóng
disturbed : bị phá rối
triggered : bóp cò (báo động).
assemble : lắp, ráp vào nhau.
components : các phần của điện tử
invidual : cá nhân, riêng
represent : thay mặt; đại diện
tie : buộc chặt; nối chặt lại.
Hint : sự mách bảo; mách nước
circuit breaker: bộ phận ngắt điện tự động.
thermal : hơi nóng
in case of : trong trường hợp của
short : chạm điện; mát.
reset : đặt lại.
circuit protection device: bộ phận bảo vệ mạch

điện là cầu chì hay bộ ngắt điện tự động.
potentially : áp điện
destructive : tàn phá
excessive : thái quá.
against : chống lại
calibrated : đo cỡ
burn : cháy
vaporize : bốc hơi (chảy)
Fuse link : cầu chì (dây)
The thin strip of Fusible metal: - Kim loại bằng chì mỏng không rõ (trần)
preset : đặt lán hơn
thin : mỏng.
thick : dày.
strip : trần (không rõ)
unsafe : không an toàn
condition : điều kiện
occur : xảy đến
handle : xử dụng
explosion : sự nổ
electrical explosion: - điện nổ. - sự nổ điện.

Home security system	:	hệ thống an toàn trong nhà.
burglar	:	Kẻ trộm
burglar alarm system	:	Hệ thống điện báo phòng trộm cấp.
Runaway current	:	Cường độ thất thoát (mất cường độ) Không kiểm soát được.
short circuit	:	mạch điện bị mát; chạm mạch.
troubleshooting	:	sự kiện sai lệch (phiền toái).
logically	:	một cách hiển nhiên
improper	:	Không thích hợp.
definition	:	sự định nghĩa.
correcting	:	đúng
connect	:	nối
automotive	:	tự động
tape	:	sợi chỉ; sợi dây.
deck	:	tạo thành
branch	:	nhánh

headlight	:	loại đèn lớn có pha-cốt ở đầu xe (ô tô)
light switch	:	công tắc của đèn.
Push buttom	:	công tắc bấm nút dùng cho kèn
Track player	:	máy hát dùng ở xe.
fast blow	:	chạy nhanh
slow blow	:	chạy chậm
major	:	lớn
react	:	chống lại
normally	:	bình thường
abnormally	:	bất bình thường
melting	:	chảy ra
vaporizing	:	bốc hơi
bimetallic	:	lưỡng kim
halt	:	đình chỉ; ngừng hoạt động.
miniature	:	thu nhỏ
inspection	:	sự thanh tra; xem xét; kiểm soát.
defective	:	bị hư

ELECTRONIC CURRICULUM

VOCATIONAL TRAINING SSON PLAN # ____ Low Voltage Circuits

Teaching Materials Source ____________________

Chapter ____________, pages ____________

Lab Manual pages ____________

Additional Instructor Materials ____________________

Main concepts student will learn:

1. to identify the five basic components required for a typical signal circuit: power source, bell transformer, push-button switch, wire, and a signal device.
2. demonstrate an ability to wire signal circuit components either in series, parallel, or in combination as directed.
3. distinguish between a signal type circuit and a power type circuit and explain the detection, control, and signaling operation of a typical security alarm system.

Technical Vocabulary

see Glossary

Related General Vocabulary

Length of Lesson

2 - 3 days

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Teaching Activity

Try to familiarize students with the applications of low voltage and low current systems in the home. Indicate that the telephone, doorbell, intercom, security alarm, antenna, smoke detector, etc. represent this type of system, and that generally the wiring of these systems requires the knowledge of some special regulations as specified in the National Electrical Code.

Mention to the class that annunciators are used quite often in signal systems where many callers must wait for service or assistance, such as in hospitals. Hit upon the two main functions of such devices: it signals when activated, and it indicates where the signal was originated. These systems also have a means to reset thereby returning the unit to its normal static position.

When discussing security alarm systems and the techniques of providing burglar protection, have students examine some floor plans to determine vulnerable entry points. Have them "think like a burglar" and develop burglar-proof alarm system.

Materials and Notes

An activity with bells, switches, etc., that can promote student comprehension and challenge their imagination involves two phases. First, handout a simple floor plan of a rural school with three rooms. The problem is for them to draw in the wiring that will allow each room to have its own bell, however, all bells are to be controlled by one central switch. Second phase involves constructions of the student's bell circuit which now can be wired and tested on a "mock-up" type board.

LOW VOLTAGE CIRCUITS

ALARM CONTROL
UNIT : Hệ thống kiểm soát điện báo.
brain : bộ óc điện tử
central unit: hệ thống trung tâm.
alarm system, hệ thống điện báo.
moditor : sự kiểm âm
detector : đèn tách sóng hướng cực (máy dò sóng)
activate : độ nhạy
protection : sự bảo vệ
interrupted : cắt đứt
violated : xâm phạm
status indicaters: biểu số liên lạc.
time delays: định kỳ thời gian.
alarm detector: máy dò điện báo.
sense : cảm thấy
entry : thủ nhận.
protected erea: khu vực được bảo vệ.
overload , bội nạp
convert : biến đổi
door bells : chuông cửa

buggers : còi điện
chimes : bộ phận phát ra âm nhạc.
combination circuit : mạch kết hợp (Series và parallel)
signaling circuit: mạch tín hiệu.
shunt # branch : mạch rẽ; nhánh.
noise : nhiễu âm.
alert : báo động
notify : làm chú ý; gây chú ý; báo cho biết.
gain : gây ra; gây cho.
attention : sự chú ý.
horn : kèn hụ
siren : còi hụ; còi báo động.
ultrasonic alarm : điện báo siêu âm.

alarm	báo thức; báo động
motion detector	máy dò hành động
invisible field	từ trường vô hình.
electrical wave	tần sóng điện.
pattern	mẫu
disturbed	bị phá quấy; phá rối.
Triggered	báo động (bóp cò)
assemble	lắp; ráp.
components	các phần của điện như Resistor, capacitor, LED...
individual	cá nhân; riêng.
tie	buộc chặt; trói; nối chặt lại.
Hint	ám chỉ; sự mách trước; mách bảo cho biết.
burglar	Kẻ trộm
burglar alarm system	Hệ thống báo động trộm cắp.
ultrasonic motion detector	máy dò hành động bằng siêu tần số (hay siêu âm).
carpet mat detector	máy dò bằng thảm điện tử.
light beam detector	máy dò bằng tia sáng đèn điện tử
magnetic contact Switch	Công tắc giao dịch nam châm (đặt ở cửa ra vào)
Key station	bộ phận mở hay tắt thống báo động.
automatic phone dialer	bộ phận điện thoại báo động tự động
control unit	đơn vị kiểm soát trung tâm các hệ thống báo động

2. WC.

LII-417-6,-1

低电压电路（LOW VOLTAGE CIRCUIT）

技術語彙

alarm control 警报控制

stand by：預備，備份

detecter：檢測器，檢波器，鑒別器.

magnetic switch：磁蛙闸阀

pressure sensor：电力感應器.

light beam：光束，光线

Bell transformer：电鈴变压器.

protection：保護.

convert …… to：轉換成……

buzzer：蜂鸣器，

chimes：諧音，配諧

combination circuit：综合电路

signaling：信號

siren：报警器

ultrasonic：超声波的，超音波的.

interconnecting line：联络电线.

fulfill：具備，符合.

security：安全.

burglar proof system：防盗系統

network：網路.

interruption：干擾，中断.

violated：妨礙 違反.

status：狀態

indicater：指示器.

time delays：時延器.

break in：打断，破坏，插入，接入.

ELECTRONIC CURRICULUM

VOCATIONAL TRAINING ON PLAN **# IV**

COMMUNICATION SYSTEMS

Teaching Materials Source ____________________
Chapter ____________, pages ____________
Lab Manual pages ____________
Additional Instructor Materials ____________________

Main concepts student will learn:

1. to explain the necessity for early man's desire to communicate with others, and describe a variety of ancient long distance communication systems.
2. identify nine fundamental communication systems and briefly indicate the general method of operation.
3. summarize the sequence of elements or processes that are involved in any basic communication system.

Technical Vocabulary

see
Glossary

Related General Vocabulary

see
Glossary

Teaching Activity

see attached

Length of Lesson

2-3 days

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Materials and Notes

1. Write the National Aeronautics and Space Administration (NASA). NASA educational and informational publications systems are designed to meet the needs of both students and educators. A listing of their materials and cost can be ordered from:

Superintendent of Documents
U.S. Government Prinitng Office
Washington, D. C. 20402

Have students make a poster depicting one or more of the communication systems discussed. Display the posters.

Emphasize that interference can disrupt even the most sophisticated communication system. Place a buzzer close to a TV and activate both while observing the TV screen, then discuss.

Teaching Activity

1. This unit was also included to provide student motivation to continue their studies, so do not bear down excessively in terms of technical specifics, but instead stress concepts with emphasis on the application of each type of communication system.

2. When discussing the first long distance communication system (telegraph) it might be helpful to relate its operation in relationship to the elements contained in any communication system. (Message-source, key-coder, wire-carry, sounder-decoder and operator-destination) use this technique for each system topic discussed.

3. This unit provides an ideal time to explain the purpose of the Federal Communication Commission (FCC). Relate that this is a governmental agency that regulates all U.S.A. "wave" transmission. Have the class explain why such an agency might be necessary.

4. The topic of computer as a system within the chain of communication devices is obvious. However, present these additional discussion areas and some interesting conversations will ensue.
   People communicating with computers
   Computers communicating with people
   Computers communicationg with other computers

Name: ____________________

Date: ____________________

COMMUNICATIONS Period: ____________________

TECHNICAL GLOSSARY

ANTENNA:	A device, made up of a pattern of wires or conducting rods, used to either send (radiate) or pick-up (receive) radio waves.
CARRY:	The medium or device used to move or carry information from one location to another. In a radio system, for example, the "carry" is high frequency AC waves or radio waves.
CODER:	A device or circuit used to shape or convert information into the proper form for transmission.
COMMUNICATION:	The process of sending (transmitting) and acquiring (receiving) understandable information.
COMPUTER:	An electric device able to accept information, process or work on that information and supply data or results. A computer usually consists of an input and output device, storage or memory circuits, arithmetic/logic units, and a control unit.
DATA:	A term used to describe information, facts or figures.
DECODER:	A device or circuit used to separate the "information" from the "carry" of a transmitted signal. The decoder reproduces the original message.
DETECTION:	The process of separating the "intellegence or information from the "carry" in a communication system.
INFORMATION:	The facts, data, programming, or intellegence added to the carry to make up a transmitted signal.
LASER:	An electronic device which emits a tight beam of light that is extremely intense and highly directional. Lasers can be used to cut materials, align items in a straight line, measure distances, and communicate.
MICROWAVE:	Extremely short length, ultra high frequency radio wave which travels at the speed of light and in a straight line. Microwaves can be used to carry information as well as to heat and cook food.
MODULATION:	The process of mixing the "intellegence or information" with the "carry" in preparation for transmission.
RADAR:	A transmission system using bursts of high frequency electrical energy at a set frequency, duration, and direction. If the projected wave strikes an object an "echo" is sent back which is used to determine the location and distance of the object.

Name: ____________________

Date: ____________________

Period: __________________

RADIO:	A communication system using radio waves of a set frequency to carry information from the transmitter to an antenna, through the air waves to a receiving antenna, and finally to the receiver and listener. Radio was the first wireless communication system able to transmit and receive voice signals.
RADIO WAVE:	High frequency electrical energy capable of traveling great distances through the air and also able to carry information. Radio frequency (RF) waves range from 20,000 cycles per second to 30,000,000,000 cycles per second.
SATELLITE:	An automated spacecraft able to perform specific jobs while orbiting around the earth. Basically, satellites are able to gather information, process that information, and transmit and receive data.
SYNC:	The process of timing or setting two or more actions to occur at the same instant. For example, in a television system the sound and picture signals must be in sync to coordinate voice and mouth movements or sound with actions.
TELEGRAPH:	An early communication system using a wire to carry electrical pulses from one location to another. A "key is used to produce and transmit a series of pulses (dots and dashes) which are received and reproduced by a "sounder." The operator must then translate the coded message into understandable language.
TELEPHONE:	A practicle communication system able to transmit and receive voice and sound signals by means of electrical impluses traveling through interconnecting wires. The transmitting device is a microphone located in the mouthpiece of the hand set, while the receiving device consists of a vibrating diaphragm located in the earpiece.
TELEVISION:	Generally, a wireless communication system which is capable of transmitting simultaneously, video (picture) and audio (sound) signals on a radio wave carry. When the TV signal is captured by the receiving antenna and fed to the receiver, it is converted back to visual pictures with synchronized sound.

SCORE:

GRADE:

Name: ____________________

Date: ____________________

Period: ____________________

WORKSHEET

VOCABULARY - KNOW YOUR DEFINITIONS

Below you will find short definitions for a number of electrical terms. Your job is to find the term that best fits the definition. If you're imaginative you might refer to your technical glossary.

EXAMPLE:

DEFINITION	TERM
A. The basic unit for measuring current.	A. AMPERE

YOUR TURN:

DEFINITION	TERM
1. The process of transmitting and receiving understandable information.	1.
2. A device or circuit used to separate the information from the signal carry.	2.
3. A system using bursts of electrical energy to determine location and distance of an object.	3.
4. High frequency electrical energy capable of carrying information through the air great distances.	4.
5. A system of communication using both video and audio signals carried by radio waves.	5.
6. The process of timing two actions to occur at the same instant.	6.
7. The medium or device used to move information from one location to another.	7.
8. The process of mixing the signal information with the carry.	8.
9. A device which produces an extremely intense, highly directional, tight beam of light.	9.
10. A communication system capable of sending information over a wire in the form of electrical pulses (dots and dashes).	10.
11. The facts, data, programing or intellegence added to the carry.	11.
12. Extremely short, ultrahigh frequency radio waves which travel at the speed of light and in a straight line.	12.

SCORE:

GRADE:

Name: ____________________

Date: ____________________

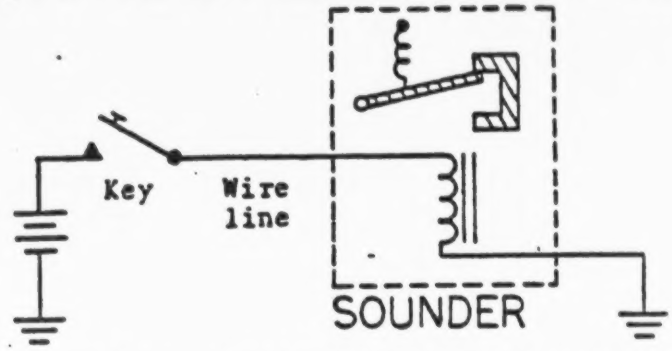
Period: ____________________

WORKSHEET

COMMUNICATION SYSTEMS

Communication plays a vital role in our existance. The systems developed to transmit information from person to person are consistently being improved, modified, or replaced with a more efficient process. Modern day communication systems employ techniques such as radio wave, microwave, and laser-light beam transmission. Below is the beginning of a description on communication systems which you are to complete and document. Follow the example given below and include a sketch or a block diagram of each system when possible along with the communication system elements.

A Telegraph System-
(Example)



Facts	System and Inventors(s):	Telegraph system patented 1843 by Samuel Morse.
	Basic Operation:	Hand operated switch (key) controls pulses of current (dots and dashes) which are assigned alphanumeric meaning.
unication n Elements	Source:	Message content.
	Coder:	Telegraph key.
	Message Carrier:	Wire/electricity.
	Decoder:	Telegraph sounder.
	Message Destination:	Electrical pulses converted to sound waves and received by human ear and translated by brain applying Morse Code knowledge (person receiving).

Name: ______________

Date: ______________

Period: ______________

B Radar System:

Source: Coder: Carrier: Decoder: Destination:	FACTS:

C Laser System-

Source: Coder: Carrier Decoder: Destination:	FACTS:

Name: ____________________

Date: ____________________

Period: __________________

D Television System

Source: Coder: Carrier: Decoder: Destination:	FACTS:

E Microwave System-

Source: Coder: Carrier: Decoder: Destination:	FACTS:

SCORE:

GRADE:

Name: ____________________

Date: ____________________

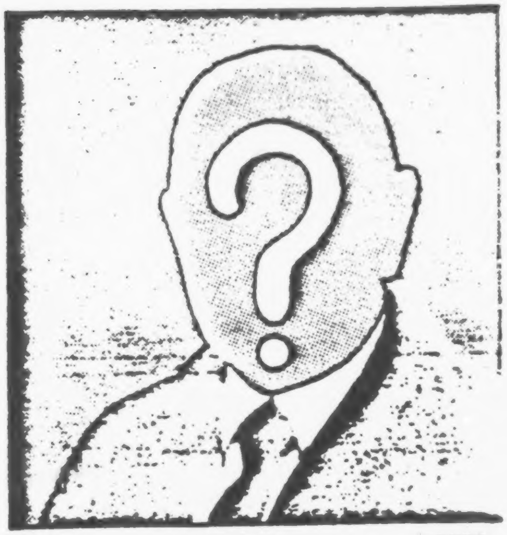
Period: ____________________

WORKSHEET

QUEST ACTIVITY

"UNIT 21"

Utilizing the biographical clues below, identify this individual. Your school library or just an Encyclopedia can serve as an important resource.



Fill in the names of the books used to solve this "Quest Activity":

1. ____________________
2. ____________________
3. ____________________

WHO AM I...

****

- Moved to the U.S.A. in 1920
- Developed the iconoscope tube
- Born in 1889
- Physicist
- Worked for RCA.
- Attended Petrograd Institute of Technology
- Pioneer in the discovery of TV
- Worked for Westinghouse
- Inventor/Engineer
- Assisted in the Development of the "Electron Microscope"
- Holds over 120 patents
- Received the National Medal of Science Award
- Raised in Russia
- Created the Kinescope

MY NAME IS.....

Name: ____________________

Date: ____________________

Period: ____________________

INFORMATIONAL HANDOUT

COMMUNICATION SYSTEMS

BACKGROUND:

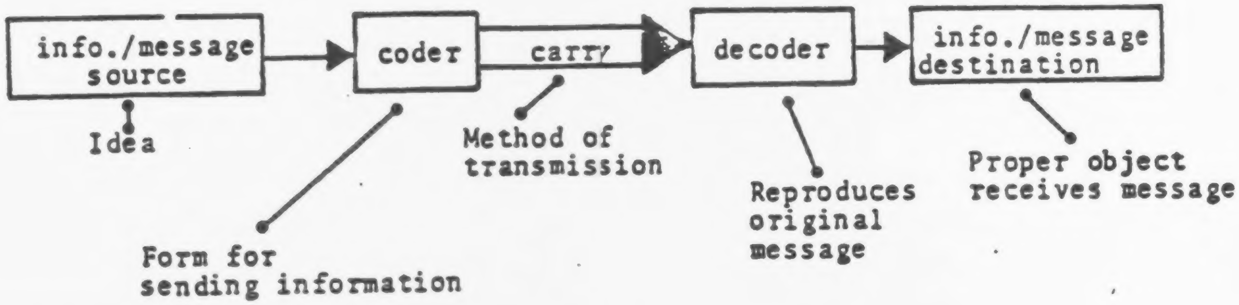
Without communication we cannot survive. A baby must communicate its need for air, food, etc. from the moment it gets life........................and there begins a fantastic process requiring communication at every step.

1 Communication: the process of giving and receiving information.

"Con-munio" (Latin word)

→ to transmit information.

2 Parts of a communication system.


info./message source
coder
carry
decoder
info./message destination
Idea
Method of transmission
Form for sending information
Reproduces original message
Proper object receives message

EARLY HISTORY:

Cave dwellers felt the need to communicate almost immediately and some early systems for communication were grunts and gestures. People joined together and formed tribes and communities and again they had to develop sounds (language). Many years passed before communication systems were able to transmit over great distances.

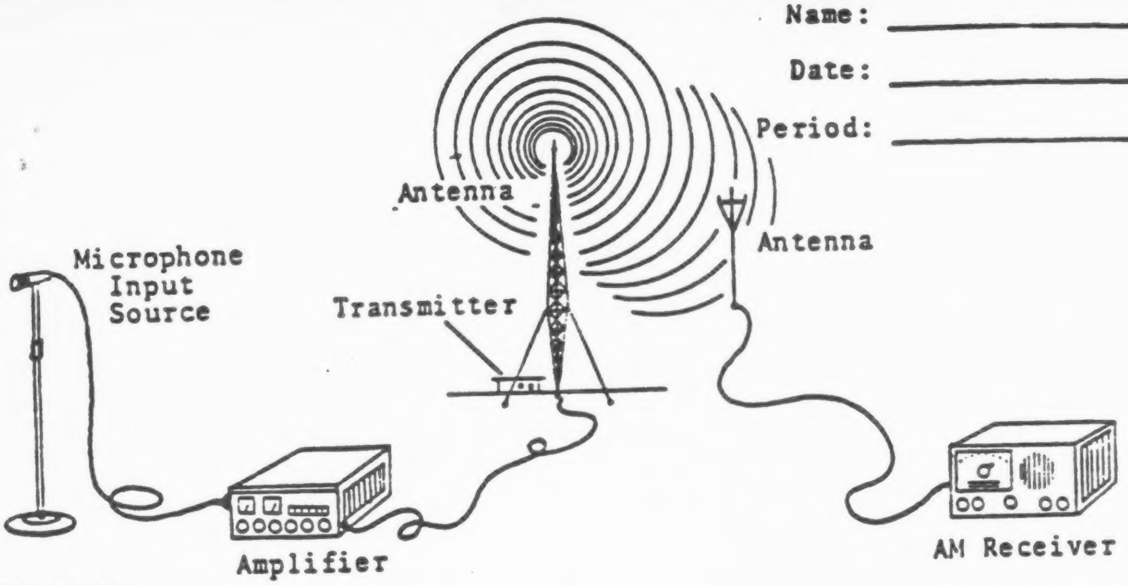
TELEGRAPH:

This system opened the door for long distance communication. Samuel Morse in 1835 invented the telegraph which is a method of sending and receiving messages by pulses (dots and dashes). The operator touches rhythmically, a device called a key, and then an electrical wire transmits the pulses to a sounder which clicks in the same manner. The clicks (dots and dashes) correspond to a specific code that represents letters from the alphabet.

Name: ____________________

Date: ____________________

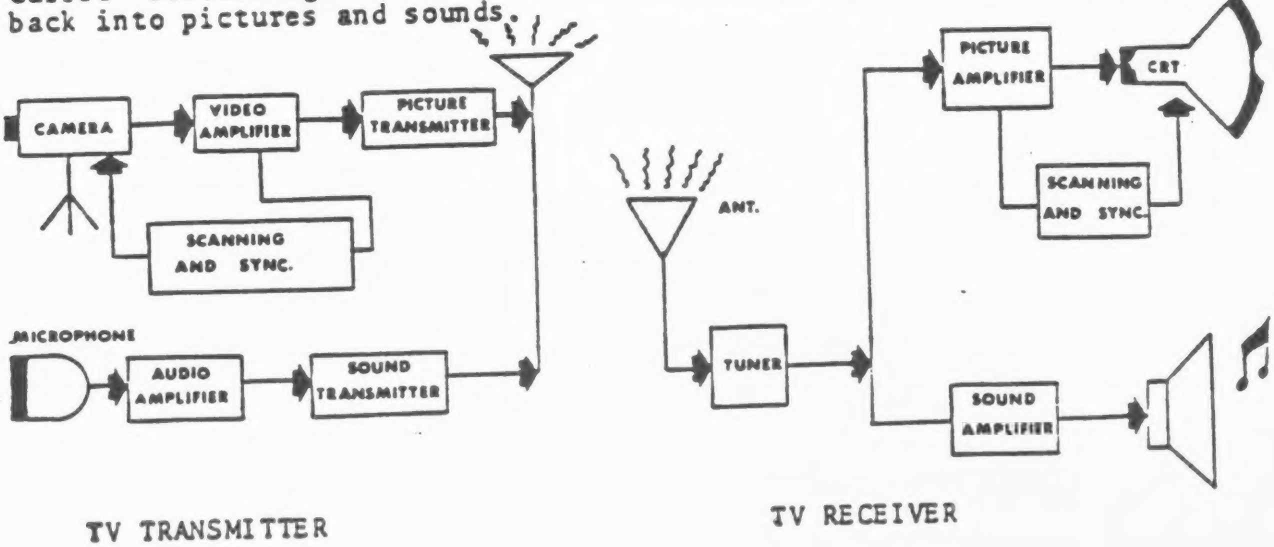
Period: ____________________


Antenna
Antenna
Microphone Input Source
Transmitter
Amplifier
AM Receiver

TELEVISION:

A system of communication which combines the sending and receiving of sound (audio) and image (video) signals. Vladmir Zworykin, John Baird, Charles Jenkins and others are credited with its development in the 1920's.

Most pictures and sounds received by a television set are beamed from a television station (camera, studio, equipment, etc.) on electronic signals called "electromagnetic waves." The television set converts these waves back into pictures and sounds.


CAMERA
VIDEO AMPLIFIER
PICTURE TRANSMITTER
SCANNING AND SYNC.
MICROPHONE
AUDIO AMPLIFIER
SOUND TRANSMITTER
ANT.
TUNER
PICTURE AMPLIFIER
CRT
SCANNING AND SYNC.
SOUND AMPLIFIER
TV TRANSMITTER
TV RECEIVER

RADAR:

This system is utilized in navigational work and in detection of objects at a distance.

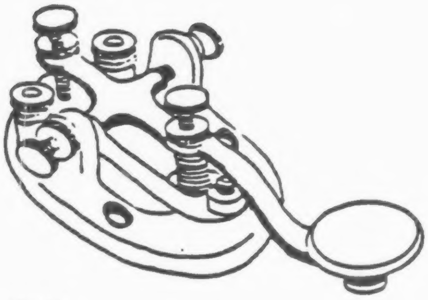
The discovery of the radar concept is attributed to L.C. Yound and A.H. Taylor, in 1922. A simple radar system consist of an aimed antenna which transmits radio signals. These signals will hit an object and bounce off creating an echo. This echo will be received and cause a tiny blip to appear on a C.R.T. screen. The direction, altitude, and distance of the object from the radar station can then be accurately computed. Radar communication systems have been proven useful in both peace and war time.

Name: ____________________

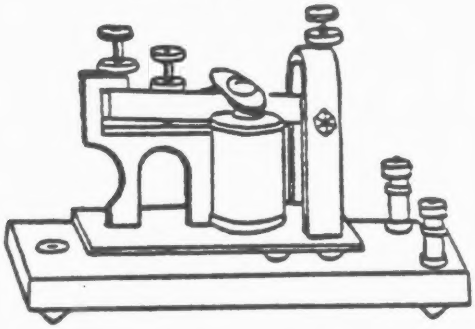
Date: ____________________

Period: ____________________

KEY

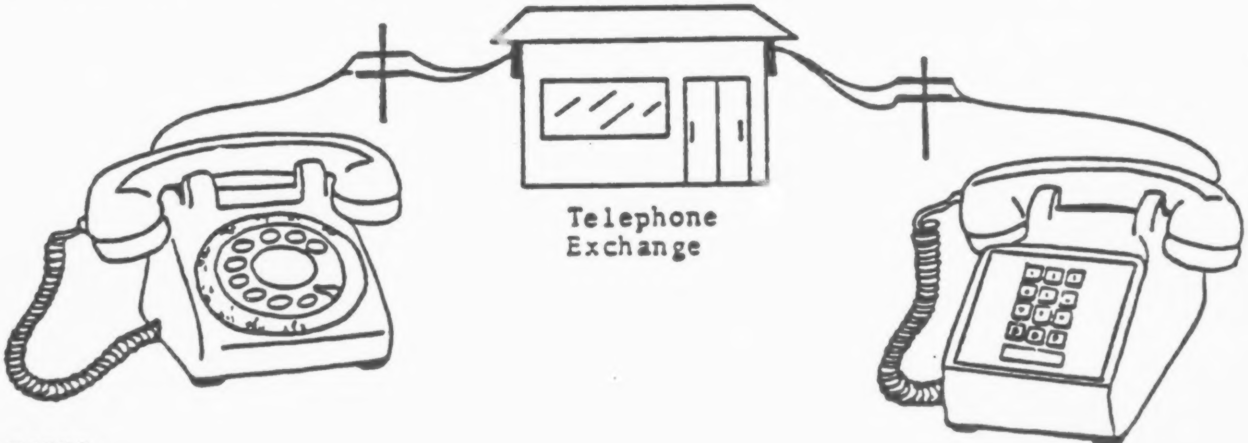


SOUNDER



TELEPHONE:

This system is used by the average person generally on a daily basis. It was invented by Alexander G. Bell and he patented the telephone in 1876. A telephone is simply a transmitter (mouthpiece) connected to a receiver (earpiece) by electrical wires. Specifically, sound causes a diaphragm to compress small carbon particles in the mouthpiece. Then the varying pressure controls and electricity to an electromagnet in the earpiece. This electromagnet causes the earpiece diaphragm to vibrate and in turn we hear a voice that sounds just like that person



RADIO:

During the early 1900's various kinds of vacuum tubes that could be used to detect and amplify radio signals were created. The development of such tubes led to the invention of radio equipment for transmitting and receivin sound. Most electronic people give credit to Reginald Fessenden of the U.S.A. for the first radio broadcast.

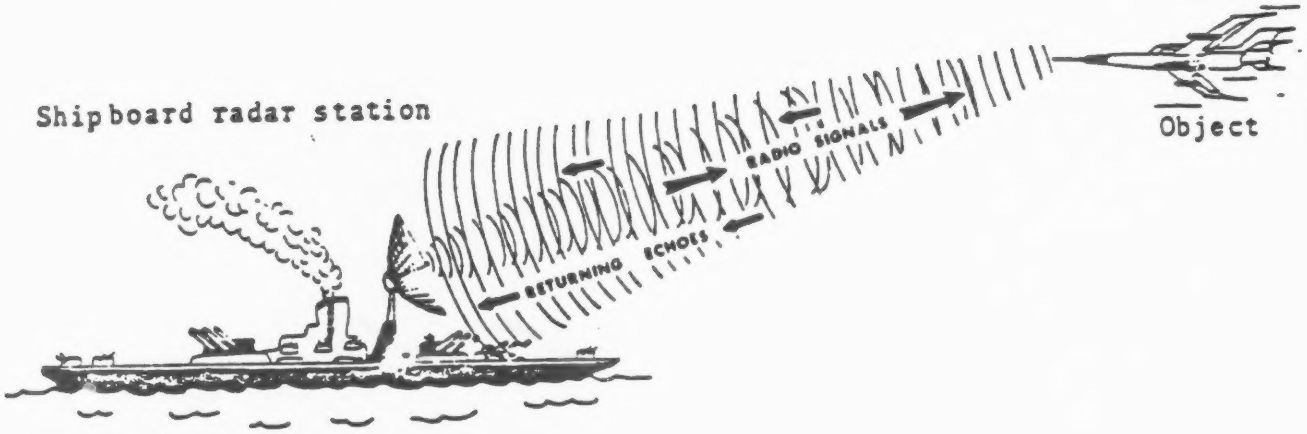
The radio transmitter made it possible to send the information with the aid of an antenna tower. The radio wave travels through the air where the signal is picked up by a radio receiver.

Other radio communication systems would include FM, and stereophonic systems.

Name: ____________________

Date: ____________________

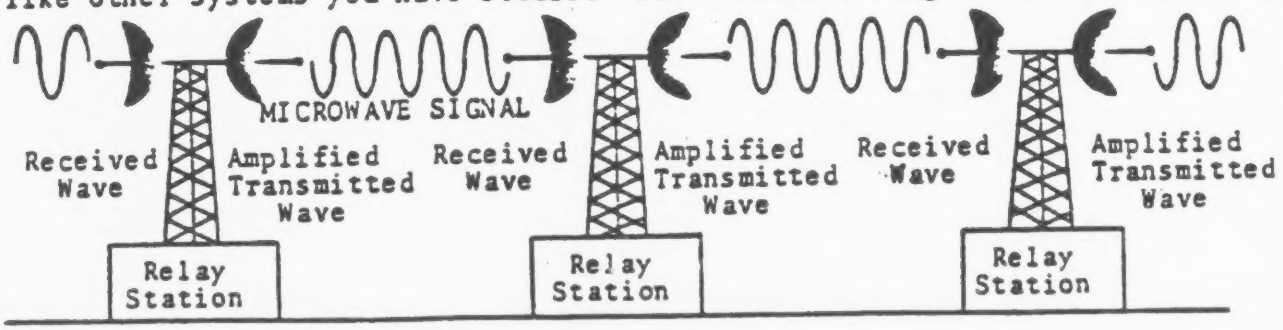
Period: ____________________


Shipboard radar station
Object
RADIO SIGNALS
RETURNING ECHOES

MICROWAVE:

This is a fairly new and efficient method of communication. Microwaves are short, ultrahigh frequency radio signals that travel at the speed of light. They carry telephone, television, telegraph, teleprinter, and other kinds of communications information.

Microwave antennas look a lot different than lower frequency antennas bec they are used like light reflectors or search lights. Microwaves can on travel in straight lines which means that for great distances many relay stations must be used. The microwave communication system operates just like other systems you have studied with a transmitting and receiving devic


MICROWAVE SIGNAL
Received Wave
Amplified Transmitted Wave
Received Wave
Amplified Transmitted Wave
Received Wave
Amplified Transmitted Wave
Relay Station
Relay Station
Relay Station

SATELLITES:

Satellites are part of a communication system between a ground station and a device in orbit around the world. Dozens of satellites are now orbiting the globe providing hemisphere-to-hemisphere communication, weather observation, and environmental information. The first satellite was launched by the Russian's in 1957 and was called "Sputnik."

Satellites generate their power from the sun to continue receiving and transmitting data for long periods of time. Many satellites gather information upon request then send this information to various tracking and communication centers throughout the world.

Name: ____________

Date: ____________

Period: ____________

The input stage provides the means to feed data into the system.

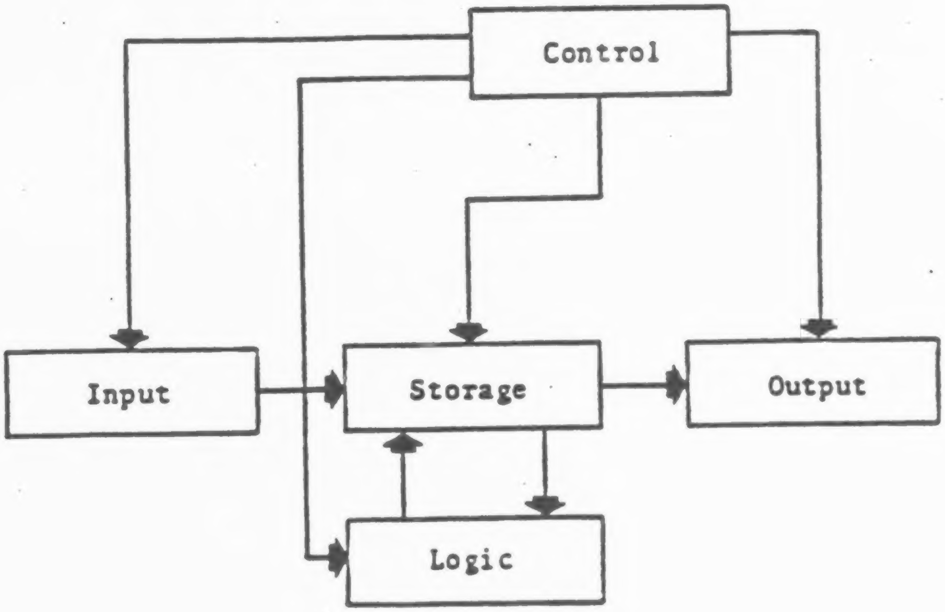
The output stage provides the means to remove data from the system.

The storage stage holds information for future processing.

The logic stage performs the mathematics in order to complete a problem.

The control stage contains the "program" of instructions for the stages to follow when completing a job.

The computer is indeed a powerful communication system now and for the future.



Computer System

UNIT EXAM

COMMUNICATION SYSTEMS

IMPORTANT:

Indicate your responses on the answer sheet only. Fill in the the box corresponding to the correct answer to each question. There is only one correct answer for each question.

1. The person who begins the communication process or system is called the message or informational source. (T - F)

2. There are five basic parts or elements of a communication system. (T - F)

3. A telegraph key is a communication device that translates electric pulses into mechanical action. (T - F)

4. A television receiver is a communication device in which visual images are traslated into electric current. (T - F)

5. The decoding element of a communication system changes data or information into a form that is meaningful to the message destination user. (T - F)

6. An audio reproducer is the technical name for a microphone. (T - F)

7. V. Zworykin, an American physicist, was one of the developers of the television communication system. (T - F)

8. A house antenna is a very important element in a cable television receiver system. (T - F)

9. The letters F.C.C. are an abbreviation for a noncommercial radio station in Washington D.C. (T - F)

10. A radar system will transmit signals that can strike an object and bounce off, thus creating a receivable echo. (T - F)

11. How many transmitters are utilized in a television broadcasting station.

    (a) 1 (b) 2 (c) 3 (d) 4

12. A laser beam is usually considered a brilliant-red beam of _______________ light.

    (a) electromagnetic (b) infrared (c) coherent (d) incoherent

13. The _________________ stage of a computer holds information for future processing.

    (a) storage (b) logic (c) control (d) output

14. Radio waves will travel at __________, and they travel in every direction from an antenna.

(a) the speed of sound (b) about 50 to 200 m.p.h.
(c) 6000,000 hertz (d) 186,000 m.p.s.

15. The first satellite was launched by the Russians and called ______________.

(a) "Beatnik" (b) "Spacenik" (c) "Sputnik"
(d) "Firstnik"

16. When a television transmitter and receiver are locked in step, teh phrase which expresses this is: "they are ____________________."

17. Satellites generally generate their own operating power from _______________ energy, however, power demands are not really that great because the ground radio receiving stations are now so sensitive and accurate that only a small signal need be transmitted.

18. Two of the human senses used in the communications process between people are speaking and ___________________.

19. In telegraph communication, the process of attaching meaning to dots and dashes heard from the decoder element is the function of the __________________ element.

20. __________________ commercial braodcast stations operate on a band of frequencies from 535 kHz to 1605 kHz.

Communication

ANTENNA : ăng-ten; dây ăng ten dùng để tiếp nhận sóng vô tuyến.
Send : gửi đi
Radiate : toả ra; gửi đi
Pick-up : thu nhận; nhặt.
Receive : tiếp nhận.
carry : mang đi
Medium : phương cách; Phương thức.
carry information : tin tức chuyển đi.
Radio wave : sóng vô tuyến.
Coder : ám số; mật mã.
to shape : biến thể.
convert : biến đổi.
proper form : hình thức riêng
for transmission : để chuyển đi (để truyền dẫn)
Communication : sự truyền thông
transmitting : truyền; gởi
acquiring : tiếp nhận.
Receiving : sự tiếp nhận.
understandable information : tin tức có thể nghe được.
Computor : máy điện cơ (điện tử).

process : dự án; chương trình.
data : dữ kiện (đưa vào máy)
input : nhập
output : phát
storge : dự trữ; chứa.
memory : ghi nhớ.
arithmetic : phép tính (toán số).
logic : lý luận
control : điều khiển; kiểm soát.
Data (p.l) ↔ Datum (Singular) dữ kiện.
Decoder : phân tách thành chữ thường (phá mật mã).
reproduce : tái bản.
original message : tin tức chính (tin tức gốc).
Detection : sự phân tách dữ kiện; sự tách sóng.
intellegence : tin tức tình báo; tin báo cáo.
facts : việc làm; hành động.

1. C

Programming	:	chương trình; kế hoạch để thực hiện.
make up	:	làm nên; tạo nên.
Laser	:	tia hồng ngoại tuyến.
emit	:	phóng ra
a tight beam of light	:	chùm tia sóng cực mạnh.
extremely	:	cực độ
intense	:	sức mạnh.
aligh	:	xếp thành hàng.
straight line	:	đường thẳng.
distance	:	khoảng cách.
communicate	:	thông đạt.
Microwave	:	sóng điện tử; vi ba.
ultra high frequency	:	tần số siêu âm; siêu tần số.
The speed of light	:	vận tốc ánh sáng 300,000,000 m/s 186,000 miles/s
Modulation	:	sự biến điệu. sự pha trộn dữ kiện.
preparation	:	dự bị; sửa soạn; chuẩn bị
Radar	:	máy Ra-đa; Hệ thống dò xét vật ở xa bằng tần số sóng cao tần để xác định vị trí, khoảng cách của vật ở xa.
burst	:	loạt sóng.
duration	:	sự liên tiếp.
direction	:	hướng trực chỉ.
projecte	:	phát sóng; phóng ra
strike	:	đập (vào).
echo	:	dội sóng; hồi ba (sóng truyền đi tới chạm vào vật rồi truyền ngược trở về)
air wave	,	sóng không khí
finally	:	chấm dứt.
Receiver	:	người nhận
listener	:	người nghe.
wireless	:	không giây; vô tuyến.
voice	:	tiếng nói, âm.
capable	:	có năng lực.
cycles per second	:	chu kỳ trên giây viết tắt cps.

2 - C

Setellite	vệ tinh nhân tạo.
spacecraft	trạm không gian.
perform	thi hành.
orbiting around the earth	quay quanh địa cầu.
timing	điều chỉnh thời gian.
action	hành động
occur	xảy đến
instant	một lúc
same instant	cùng một lúc
Coordinate	- tọa độ - ngang bằng; sánh bằng.
telegraph	điện tín
pulse	đẩy; xung động
one location to another	từ vị trí này đến vị trí khác.
Sounder	máy ghi nhận (morse).
operator	người phụ trách máy.
translate	dịch
dots	chấm (. : tích)
dashes	gạch (– : tè)
telephone	điện thoại.
Sound	âm thanh
Voice	tiếng nói

interconnecting wire	dây nối.
microphone	ống vi âm; ống nói; hệ thống thâu âm.
the mouth piece of the handset	bộ ống nghe và nói cầm tay ở điện thoại.
Vibrating diaphram	màng rung động
earpiece	ống nghe.
television (T.V)	truyền hình, vô tuyến truyền hình.
Radio	vô tuyến truyền Thanh.
simutaneous	cùng một lúc.
Video	hình ảnh.
audio	âm thanh.
capture	bắt lấy; thu.
fed	đưa đến
visual	thấy; trông thấy
invisual	Không thấy được.
synchronized	ăn khớp; đồng bộ (thường viết dưới dạng Sync)
fit	thích hợp
imaginative	tưởng tượng
communication plays	Sự truyền tống kịch truyện.

3-C

plays : vở kịch.
vital : trọng yếu.
role : vai trò.
existance : sự sinh tồn.
consistently : một cách hoà hợp.
improved : được cải tiến.
modified : thay đổi
repla : thay thế
technique : kỹ thuật
deseription : sự mô tả
document : dạy dỗ.
along with : cùng với.
inventor : người phát minh
patented : được phát minh
assign : chỉ rõ; phân phát
message content : chứa đựng tin tức; thư tin tức.
message distination : chỗ nhận tin tức.
distination : nơi đến, đích đến.
clue : rắc rối; phức tạp.
resouree : phương sách; tài nguyên.
attend : tham dự.
Institude : Viện; học viện.
Pioneer : người tiên phương; người mở đường.
medal : huy chương
Raised : được sinh trưởng

created : đã sáng lập ra; (sáng tạo nên)
diaphram : màng
compress : băng vải
vibrate : rung động
credit : tín dụng.
broadcast : truyền thanh.
tower : pháo đài
stereophonic : lược sóng; âm thanh nổi.
FM : băng tần FM ở Radio.
camera : ống kính, máy chụp hình.
studio : phòng chiếu phim.
video amplifier : ảnh phóng đại
amplifier : phóng đại.
ANT : thu nhận
navigational : hàng hải.
detection : sự thăm dò.
concept : ý niệm.
attribute : qui công.
blip : điểm (hình) hiện trên màn ảnh của rađa.
tiny : rất nhỏ, nhỏ li ti
Peace : hoà bình
war : chiến tranh
teleprinter : điện ấn.
reflector : phản chiếu (rọi)
search : dò xét

4-C

relay station : trạm tiếp vận.

globe : quả địa cầu.

orbit around the world : quay vòng quanh thế giới.

hemisphere : bán cầu

hemisphere to hemisphere : bán cầu này đối bán cầu kia.

wea , thời tiết

weather observation : sự quan sát thời tiết.

environment (n) · vùng xung quanh; lân cận ; sự bao vây.

environmental (adj) xung quanh ; lân cận

environmental information : tin tức lân cận ; tin tức xung quanh.

launch : phóng ra (đưa lên không trung)

Request : đòi hỏi ; yêu cầu ; hỏi.

various : Khác nhau

track : lối đi

various tracking : lối khác nhau.

center : trung tâm.

Ground tracking Station : lối phát sóng từ trạm dưới đất đến vệ tinh. (truyền vận địa. không).

optical (a) : quang học

optical communication : sự truyền tống quang học.

propose : đề nghị.

real : thực tại

ability : năng lực; khả năng.

Reliability : Sự đáng tin cậy

mass : khối lượng.

insufficient , thiếu thốn

Technology : Kỹ thuật

Rapidly : một cách nhanh chóng

Modulater : bộ phận biến điệu máy biến điệu.

feed data : nuôi dưỡng dữ kiện.

indeed : quả thật ; thật vậy.

problem : vấn đề ; chương trình.

powerful : đầy năng lực.

LII-421-6,-7

通信 (communication)

技術語彙

antenna：天线

radiate：輻射，发射

pick-up：接收.

carry：传送，載波.

coder：編碼器

shape：造型，成型，整形.

communication：通訊，通信.

computer：計算机，电腦

storage：儲存

memory：記憶

arithmetic：算術

logic：邏輯，條理.

data：資料，數據.

describe：記述

decoder：譯碼器，解碼器

separate：識别，分類，分開.

detection：檢波，檢查.

intelligence：通訊，情报，报導.

laser：激光，雷射光

tight beam：緊密的光束

intense：激烈，熱烈的.

align：調整，校直，調準，匹配

microwave：微波、

modulation：調制、調節.

radar：雷達

burst：无线电脈衝，正弦波群，短脈衝群，猝发，爆裂.

duration：時间持續，持續性

L22-U21-13.-16

projected: 投影,投射,射出的.

strikes: 碰,撞.

echo: 回聲,回波,反射波.

radio: 无线电信(訊),(廣播)

satellite: 衛星,人造衛星,跟班.

spacecraft: 太空飛行器

orbiting: 繞(地球)周圍的軌道迴轉

sync: = synchro 同步的,同步机

coordinate: 同等的,同位的,对等的.

telegraph: 电报,电报机,打电报.

pulses: 脈衝,瞬间波动,有規律地輸送.

dots and dashes: 点及短线.

translate: 翻譯.

telephone: 电話,电話机,打电話

impulse: 脈衝.

microphone: 传話器,传声器,微音器

vibrating diaphragm: 振動板(膜)

hand set: 手持(电話机)送受器.

television: 电視,电視机

video: 电視像,視頻的.

audio: 声音的.声頻的,音頻的.

captured: 接收到

fed: 輸送進入.

visual: 可見的,可以被看見的.

vital: 维持生命所必需的.極重要的.

role: 角色,任務

existence: 存在,生活,生存.

improved: 改良

modified: 改進,修改

replaced: 換代

Morse Code: 莫爾斯电碼.

survive: 生存.

LII-U21,-17

click：喀搭声.

tracking：航路,线路

antenna tower：天线塔.

stereophonic：立体音響的,立体音效的

image：影像,鏡像、图像.

camera：攝影机,照相机

studio：攝影室,廣播室,攝影场.

navigational：航空的,航海的.

tiny blip：很微小的影像.

C.R.T. screen：cathode-ray tube
陰極射線管銀幕

teleprinter：印字电报机,电传印刷机

reflectors：反射器

relay station：中继台,中继站.

hemisphere 半球(形)

observation：觀測

environmental：環境的.

launch：(船)下水,(飛弹)發射.

ELECTRONI CURRICULUM

VOCATIONAL TRAININ SON PLAN **# IX** Graphic Illustrations

Teaching Materials Source ____________________

Chapter __________, **pages** __________

Lab Manual pages __________

Additional Instructor Materials ____________________

Main concepts student will learn:

1. to read and draw a number of technical symbols that represent components commonly utilized in basic circuits.
2. identify the various kinds of data which accompanies a circuit symbol but are not themselves a part of the symbol.
3. distinguish and interpret the four major types of diagrams generally encountered by electronics personnel.

Technical Vocabulary

see Glossary

Related General Vocabulary

see Glossary

Teaching Activity

Materials and Notes

1. Have several examples of each component in the room for identificaiton. Each student should be able to identify the component by sight, know the letter symbol, and the schematic symbol.
2. Students should also know the abbreviations.

Length of Lesson

2 - 3 days

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

UNIT EXAM

GRAPHICAL ILLUSTRATIONS

IMPORTANT-
Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. Pictorial diagrams are difficult to read. (T-F)

2. Schematic diagrams are usually drawn to read from left to right. (T-F)

3. A schematic diagram shows the location of the components used in a circuit. (T-F)

4. A schematic diagram shows auxiliary devices such as terminals and sockets. (T-F)

5. The connecting lines on a schematic diagram should be drawn either horizontally or vertically, whenever possible. (T-F)

6. A typical reference designation uses a number/letter code such as 3_R to designate resistor 3. (T-F)

7. A pictorial diagram shows circuit components as graphic symbols and the location of the components on the chassis. (T-F)

8. A schematic diagram makes it impossible to trace the current flow through a circuit from beginning to end. (T-F)

9. On a schematic diagram, the components are represented by means of graphic sketches. (T-F)

10. The dot symbol on a schematic diagram is used to show that wires are electrically connected at that point. (T-F)

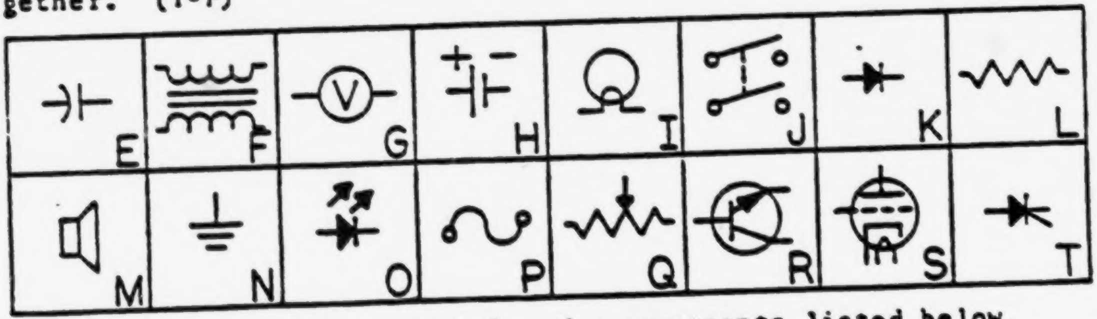
11. The wires represented on a wiring diagram are often color coded for the purpose of making it easier to lose them in the actual circuit assembly. (T-F)

12. Unlike a pictorial diagram, a schematic diagram does not show the location of components or the wires which connect the components. (T-F)

13. Block diagrams use simple shapes, and lines to show the signal flow between stages in a system. (T-F)

14. Abbreviations and letter designations are assigned to components in a diagram for ease of identification. (T-F)

15. The block diagram of an amplifier might also include a portion of the schematic diagram to assist in connecting the various stages together. (T-F)



Identify the graphic symbol for the components listed below. Record the schematic letter which corresponds to the listed component.
EXAMPLE: 100. Silicon controlled rectifier - 100. T

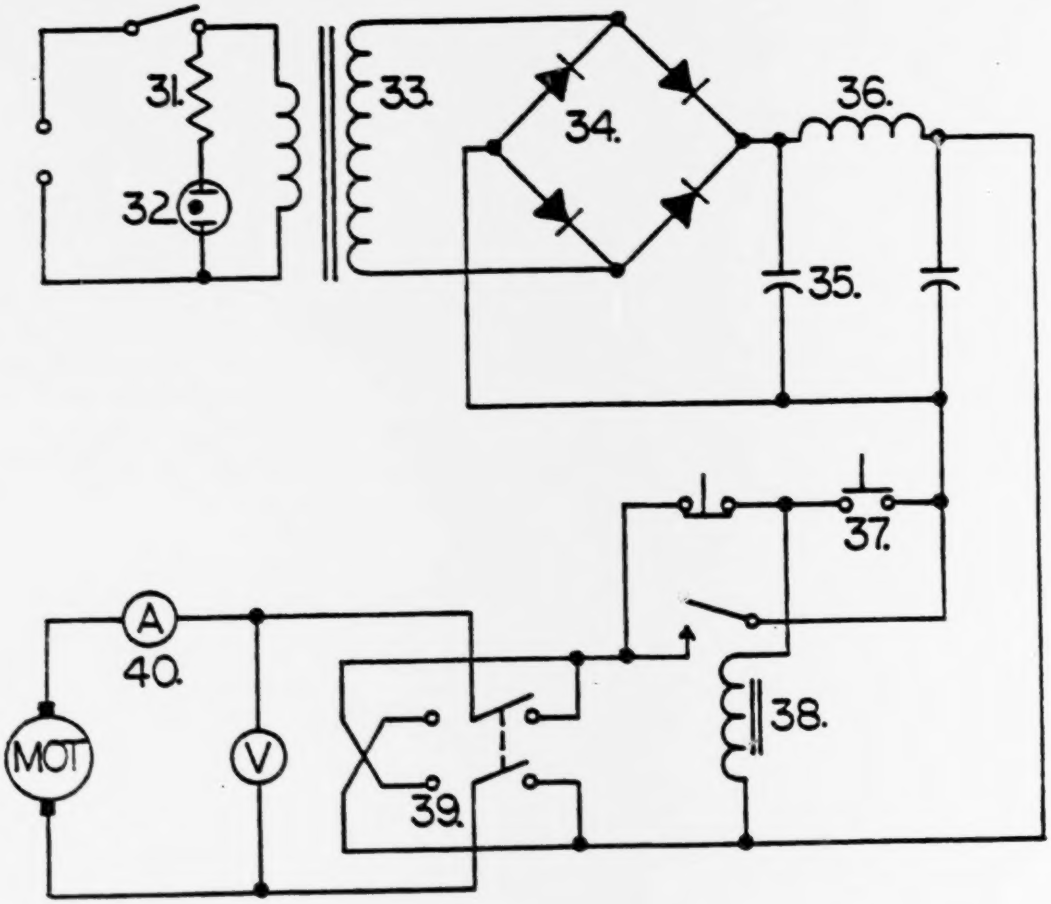
COMPONENT

16. resistor
17. triode tube
18. DPST switch
19. speaker
20. incandescant lamp
21. capacitor
22. diode
23. fuse

COMPONENT

24. ground
25. cell
26. transistor
27. transformer
28. light emitting diode
29. voltmeter
30. variable resistor

Indicate the reference designation for the components marked in the schematic.


31.
32.
33.
34.
35.
36.
37.
38.
39.
40.
A
V
MOT

31. ____________

32. ____________

33. ____________

34. ____________

35. ____________

36. ____________

37. ____________

38. ____________

39. ____________

40. ____________

Name: ____________________

Date: ____________________

Period: ____________________

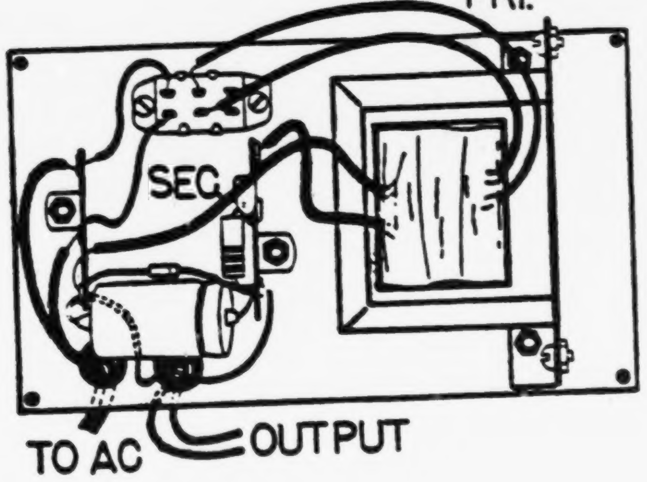
GRAPHIC ILLUSTRATIONS
TECHNICAL GLOSSARY

ABBREVIATION:	The expression of a word, or term in shortened form, usually by using representative letters. Example: The term resistance is abbreviated with the letter R.
BLOCK DIAGRAM:	A drawing in which complete circuits, or components of a circuit are represented as "functional" blocks.
COMPONENT:	An electronic part.
CONNECTION:	The junction of several conductors or components in an electrical circuit.
GRAPHIC SYMBOL:	A symbolic representation used to depict an electronic component and often referred to as a schematic symbol.
LETTER IDENTIFICATION:	A letter used to designate a particular type of electronic component. Example: The letter identification for a capacitor is C.
NUMERICAL VALUE:	The rating or value of a component expressed in its unit of measurement. The numerical value of a one thousand ohm resistor for example can be expressed as 1000 or 1k.
PICTORIAL DIAGRAM:	A drawing showing the components of a circuit, their location upon the chassis, and how they are connected together. The diagram is usually drawn to scale.
REFERENCE DESIGNATION:	The symbol used to represent components in a circuit diagram. The reference designation combines a letter identification and a subscript, to identify one particular component. The designation for resistor three on a schematic diagram would be R_3.
SCHEMATIC DIAGRAM:	A special type of drawing used in electronics to represent circuit components and connections. This type of diagram uses simplified symbols to show electric connections, but does not show the physical layout or part structure.
STAGE:	A unit which is composed of an electronic circuit or circuits which performs a function and operates as a interacting portion of a complete system.
SUBSCRIPTS:	Small identifying numbers or letters written slightly to the right of and below the quantity being identified.

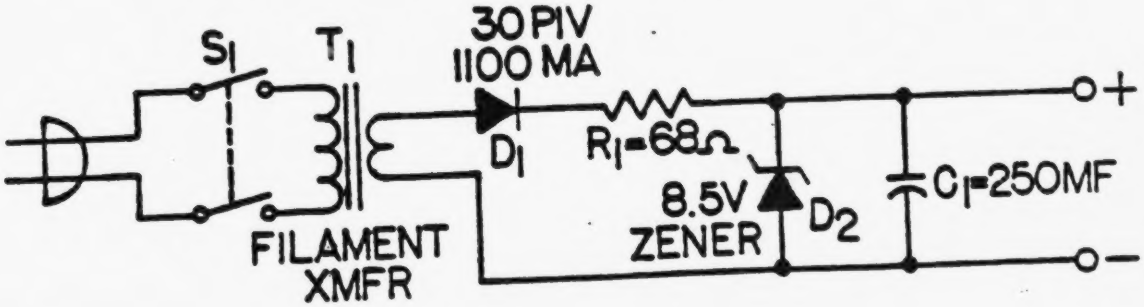
Name: ____________________

SYSTEM:	A total electronic unit comprised of interacting stages.
WIRING DIAGRAM:	A drawing used to show wiring connections in a simplified, easy - to - understand manner.

WIRING DIAGRAM


PRI.
SEC
TO AC
OUTPUT

EQUIVALENT SCHEMATIC DIAGRAM


30 PIV
1100 MA
S1
T1
D1
R1=68Ω
8.5V
ZENER
D2
C1=250MF
FILAMENT
XMFR
+
−

REGULATED 9V POWER SUPPLY

SCORE:

GRADE:

Name: ______________

Date: ______________

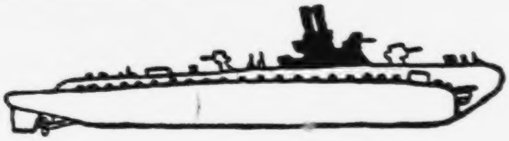
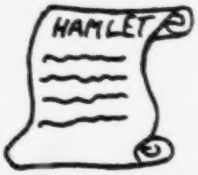
Period: ______________

WORKSHEET

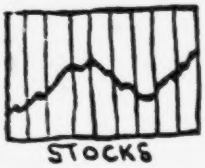
GLOSSARY CRYPTICS

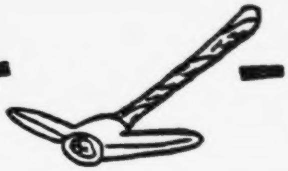
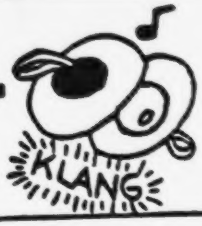
Decode the cryptic messages below to identify the electronic term.

EXAMPLE:

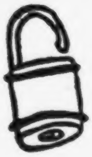
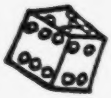
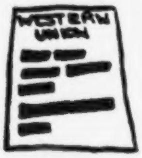
A.  + 

A. subscript

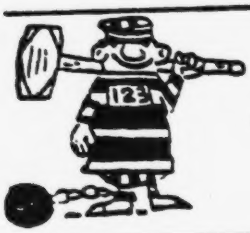
1. 

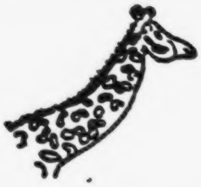
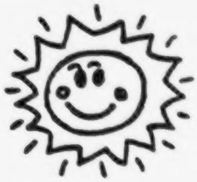
+  – P + 

1. ______________

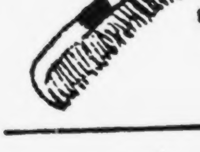
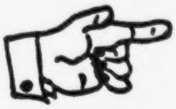
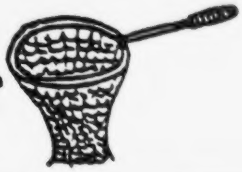
2. B +  +  + 
WESTERN UNION
– Tele

2. ______________

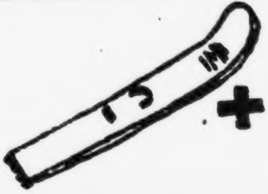
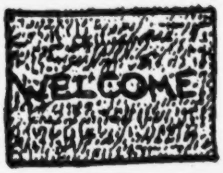
3. 

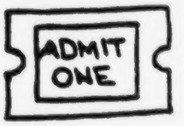
+  + 

3. ______________

4.  +  – int + 

4. ______________

5.  + 

+ 

– ket

5. ______________

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

ELECTRONIC GRAPHICS

A. Draw in the correct graphic symbol for the following electronic components.

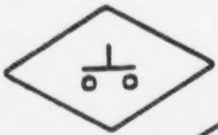
1. Incandescent lamp:
2. Fuse:
3. Fixed value capacitor:
4. Potentiometer : (variable resistor)
5. Cell:
6. Electrolytic capacitor:
7. Air core inductor:
8. Iron core transformer:
9. Chassis ground:
10. Center tapped transformer:
11. PBNO switch:
12. Ammeter:
13. Triode tube:
14. SCR:
15. AC generator:

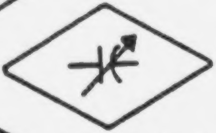
Name: ____________________

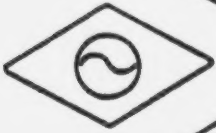
Date: ____________________

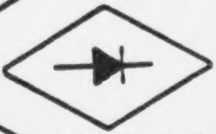
Period: ____________________

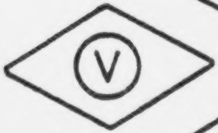
B. Identify the following graphic symbols:

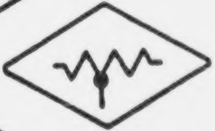
16.  . . . . ____________________

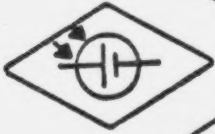
17.  . . . . . . ____________________

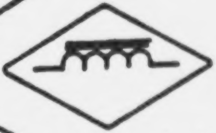
18.  . . . . ____________________

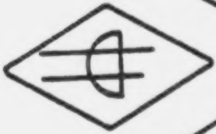
19.  . . . . . . ____________________

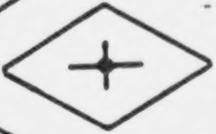
20.  . . . . ____________________

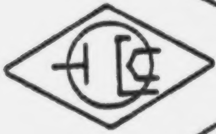
21.  . . . . . . ____________________

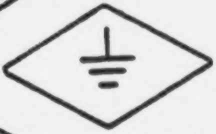
22.  . . . . ____________________

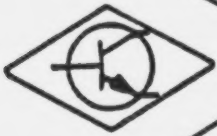
23.  . . . . . . ____________________

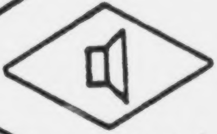
24.  . . . . ____________________

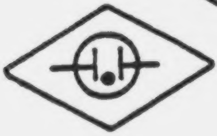
25.  . . . . . . ____________________

26.  . . . . ____________________

27.  . . . . . . ____________________

28.  . . . . ____________________

29.  . . . . . . ____________________

30.  . . . . ____________________

Name: ______________

Date: ______________

Period: ______________

C. Give the letter identification or abbreviation for the following.

31. current: ____
32. switch: ____
33. vacuum tube: ____
34. light emitting diode: ____
35. battery: ____
36. milli: ____
37. ampere: ____
38. second: ____
39. average: ____
40. ground: ____
41. capacitance: ____
42. voltage: ____
43. peak to peak: ____
44. radio frequency: ____
45. resistor: ____
46. thermocouple: ____
47. plug: ____
48. relay: ____
49. OHM: ____
50. hertz: ____

D. Identify the following letter identification or abbreviations.

51. f: ______________
52. C: ______________
53. J: ______________
54. S: ______________
55. Q: ______________
56. DC: ______________
57. db: ______________
58. X_L: ______________
59. k: ______________
60. EFF: ______________
61. p: ______________
62. AM: ______________
63. Z: ______________
64. E: ______________
65. VHF: ______________
66. SPDT: ______________
67. D: ______________
68. F: ______________
69. IN: ______________
70. PK: ______________

SCORE:

GRADE:

Name:________________

Date:________________

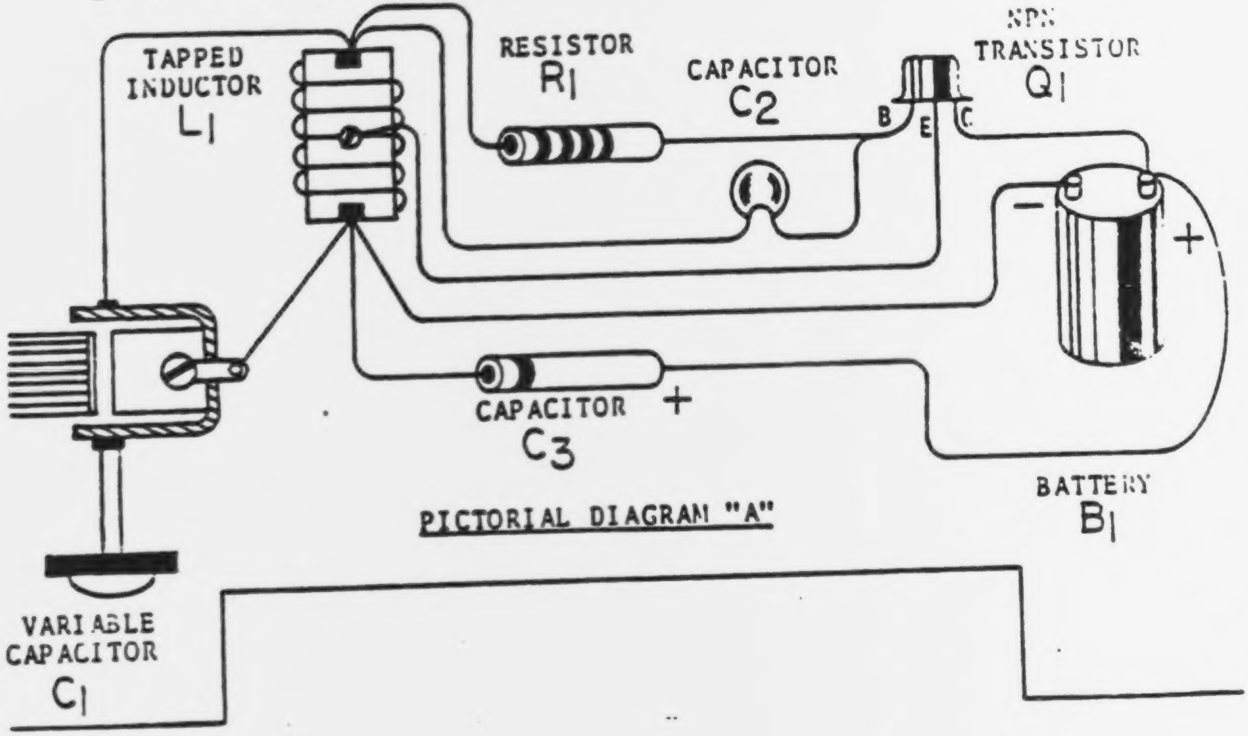
Period:________________

WORKSHEET

QUEST ACTIVITY

"UNIT 5"

Carefully study pictorial diagram "A" below. Identify the components, and pay particular attention to the interconnecting wires. Your assignment is to convert pictorial diagram "A" into a schematic diagram. Use proper schematic form. -- Good Luck.


TAPPED
INDUCTOR
L1
RESISTOR
R1
CAPACITOR
C2
NPN
TRANSISTOR
Q1
B
E
C
−
+
CAPACITOR
C3
+
BATTERY
B1
VARIABLE
CAPACITOR
C1

PICTORIAL DIAGRAM "A"

SCHEMATIC DIAGRAM

LIII-US-15

Name: ____________________

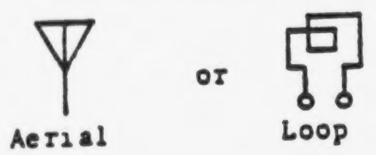
Date: ____________________

Period: ____________________

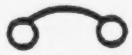
INFORMATIONAL HANDOUT

GRAPHIC SYMBOLS

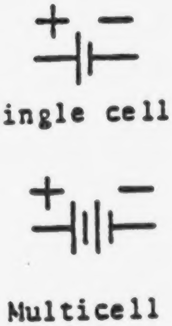
Illustrated below is a list of graphic symbols commonly used to depict electrical and electronic devices and their connection into a circuit. Currently accepted letter designations and unit abbreviations are also provided.


Aerial
or
Loop

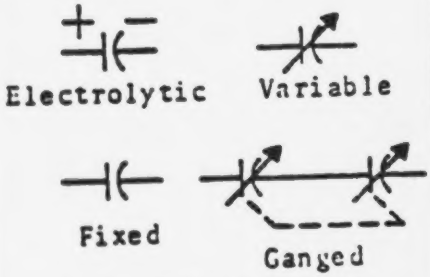
ANTENNA (ANT)



CIRCUIT BREAKER (CB)

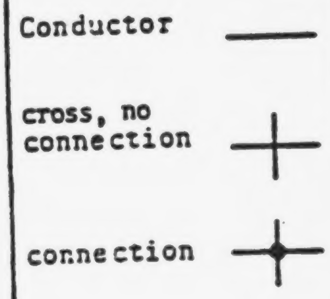

+
−
Single cell
+
−
Multicell

BATTERIES (B)

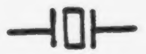

+
−
Electrolytic
Variable
Fixed
Ganged

CAPACITORS (C)

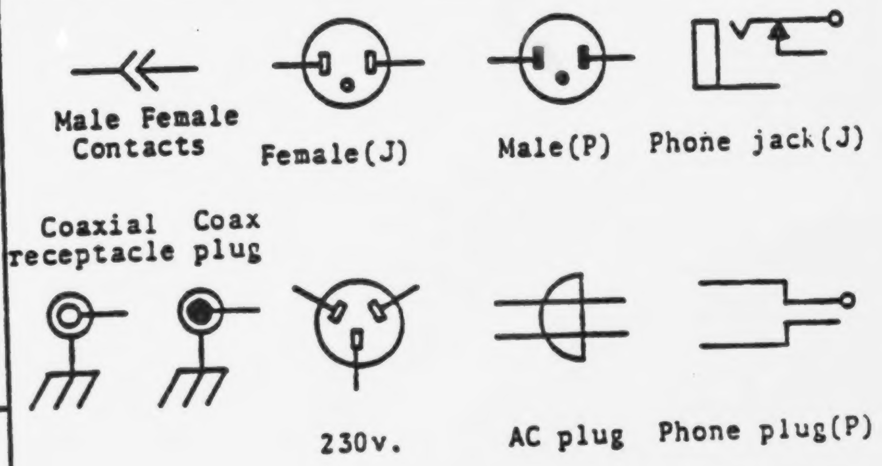
Basic Unit - Farad(F)


Conductor
cross, no connection
connection

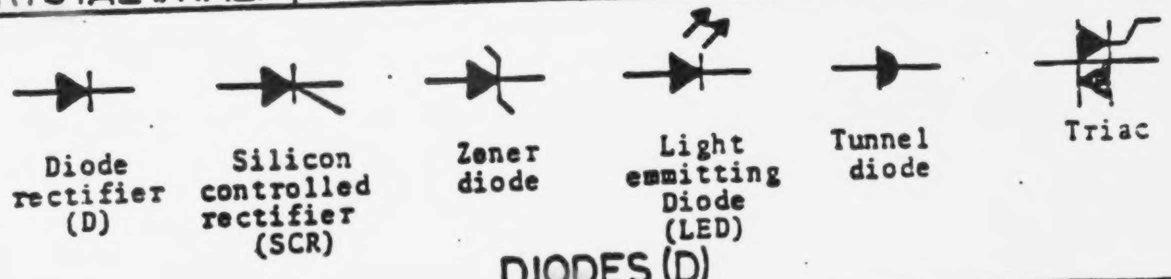
CONDUCTOR



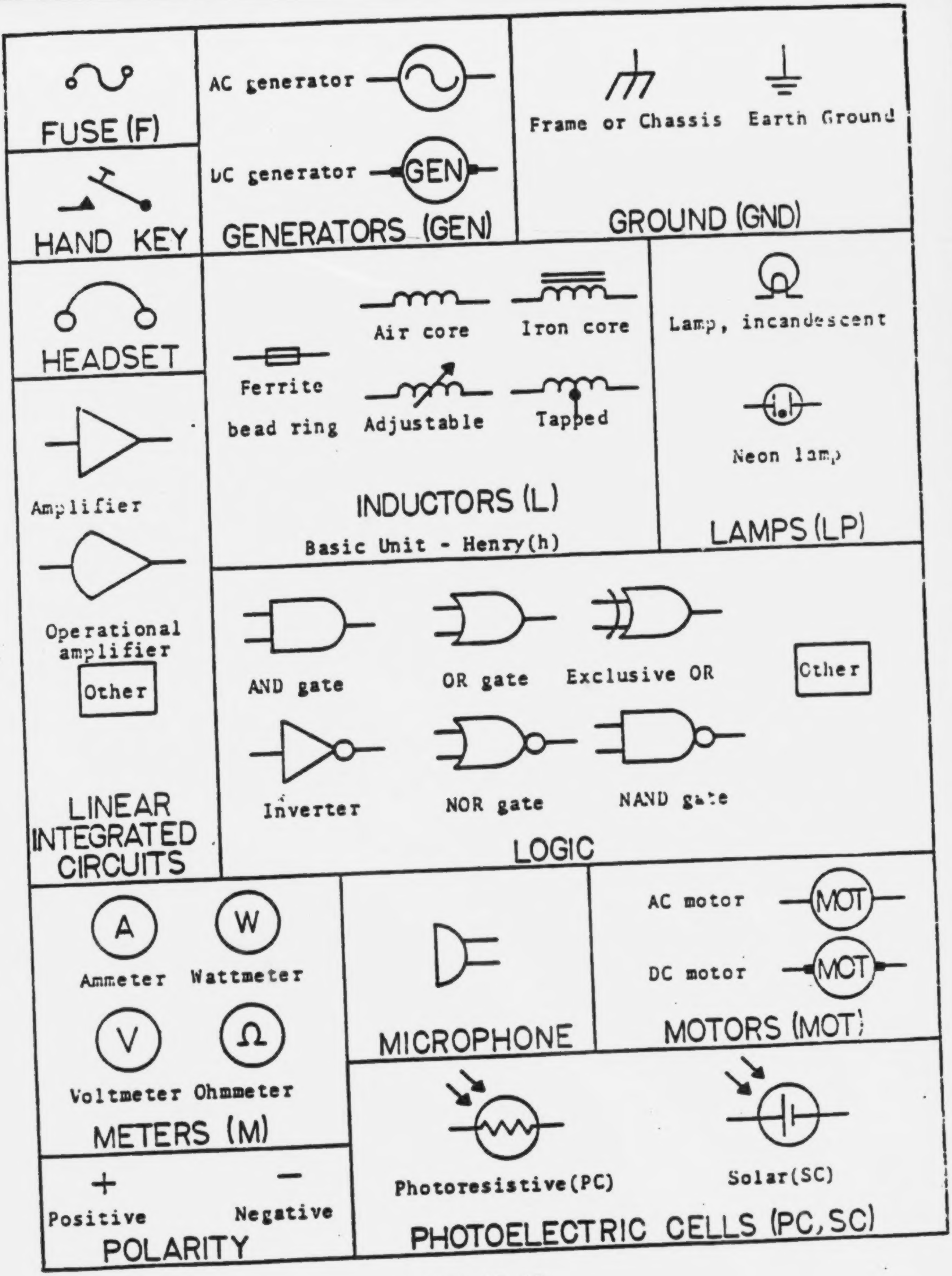
CRYSTAL (XTAL)

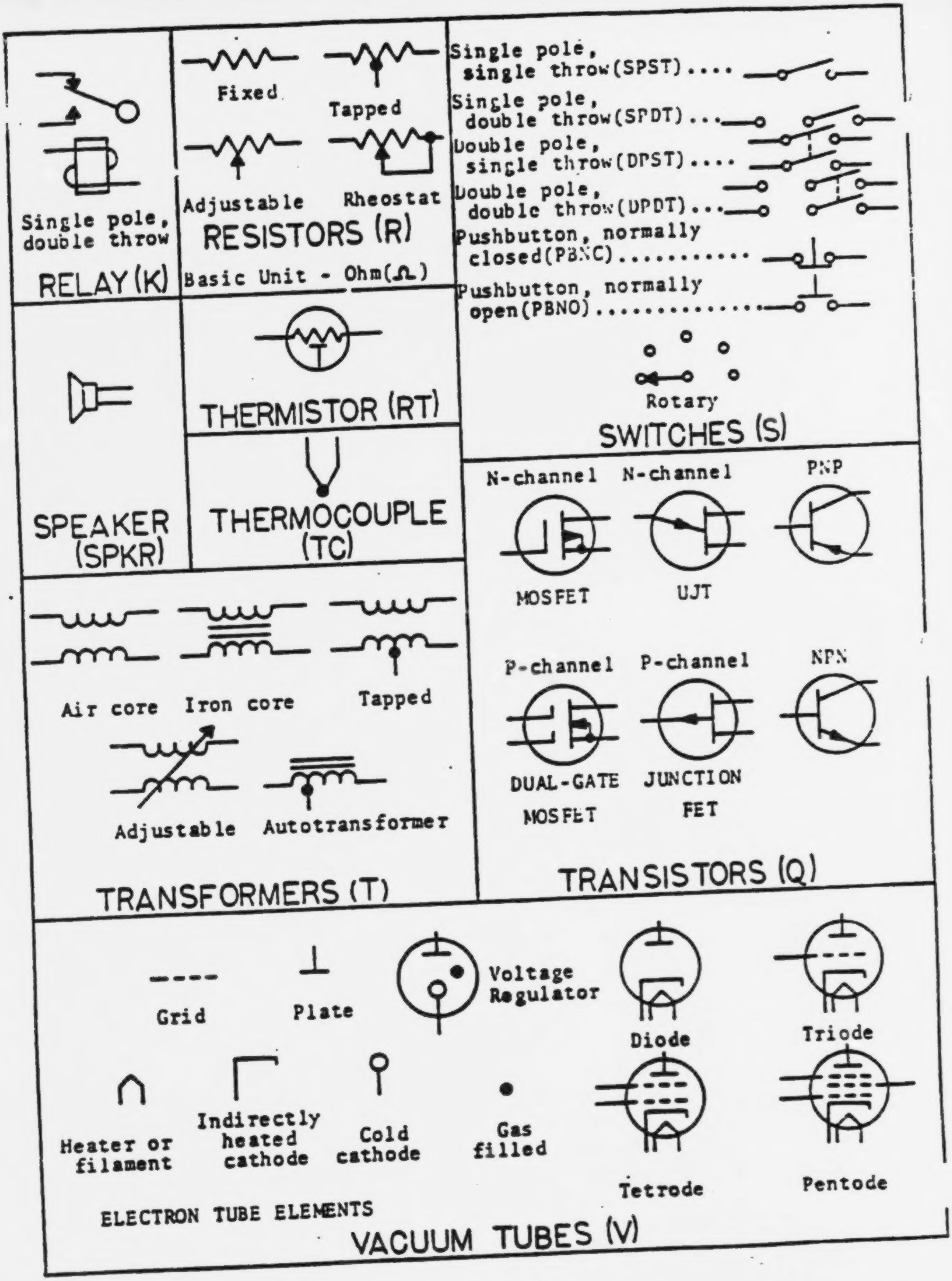

Male Female Contacts
Female(J)
Male(P)
Phone jack(J)
Coaxial receptacle
Coax plug
230v.
AC plug
Phone plug(P)

CONNECTORS


Diode rectifier (D)
Silicon controlled rectifier (SCR)
Zener diode
Light emmitting Diode (LED)
Tunnel diode
Triac

DIODES (D)


FUSE (F)
HAND KEY
AC generator
DC generator
GEN
GENERATORS (GEN)
Frame or Chassis
Earth Ground
GROUND (GND)
HEADSET
Air core
Iron core
Ferrite bead ring
Adjustable
Tapped
INDUCTORS (L)
Basic Unit - Henry(h)
Lamp, incandescent
Neon lamp
LAMPS (LP)
Amplifier
Operational amplifier
Other
LINEAR INTEGRATED CIRCUITS
AND gate
OR gate
Exclusive OR
Other
Inverter
NOR gate
NAND gate
LOGIC
A
W
Ammeter
Wattmeter
V
Ω
Voltmeter
Ohmmeter
METERS (M)
MICROPHONE
AC motor
MOT
DC motor
MOT
MOTORS (MOT)
+
−
Positive
Negative
POLARITY
Photoresistive(PC)
Solar(SC)
PHOTOELECTRIC CELLS (PC, SC)


Single pole, double throw
RELAY (K)
Fixed
Tapped
Adjustable
Rheostat
RESISTORS (R)
Basic Unit - Ohm(Ω)
Single pole, single throw(SPST)....
Single pole, double throw(SPDT)...
Double pole, single throw(DPST)....
Double pole, double throw(DPDT)...
Pushbutton, normally closed(PBNC)...........
Pushbutton, normally open(PBNO).............
Rotary
SWITCHES (S)
SPEAKER (SPKR)
THERMISTOR (RT)
THERMOCOUPLE (TC)
N-channel
MOSFET
N-channel
UJT
PNP
P-channel
DUAL-GATE MOSFET
P-channel
JUNCTION FET
NPN
TRANSISTORS (Q)
Air core
Iron core
Tapped
Adjustable
Autotransformer
TRANSFORMERS (T)
Grid
Plate
Voltage Regulator
Diode
Triode
Heater or filament
Indirectly heated cathode
Cold cathode
Gas filled
Tetrode
Pentode
ELECTRON TUBE ELEMENTS
VACUUM TUBES (V)

The following abbreviations are standards adopted by the Institute of Electrical and Electronic Engineers (IEEE).

TERM	
alternating current	AC
ampere or amp	A
amplitude modulation	AM
audio frequency	AF
average	AVG
capacitance	C
capacitive reactance	X_C
conductance	G
counter electromotive force	CEMF
current	I
cycles per second	cps
decibel	db
direct current	DC
effective	EFF
electromotive force	EMF
farad	F
frequency	f
frequency modulation	FM
ground	GND
henry	h
hertz	Hz
impedance	Z
inductance	L
inductive reactance	X_L
input	IN
kilo	k
kilowatt-hour	kwh
mega	M
micro	μ
micro-micro	μμ
milli	m
nano	n
ohm	Ω
output	OUT
peak to peak value	p-p
peak value	PK
period	T
pi	π
pico	p
positive	+
power	P
radio frequency	RF
reactance	X
resistance	R
root mean square	RMS
second	s
sine wave	∼
time	t
ultra high frequency	UHF
very high frequency	VHF
volt	V
voltage	E
watt	W
wavelength	λ

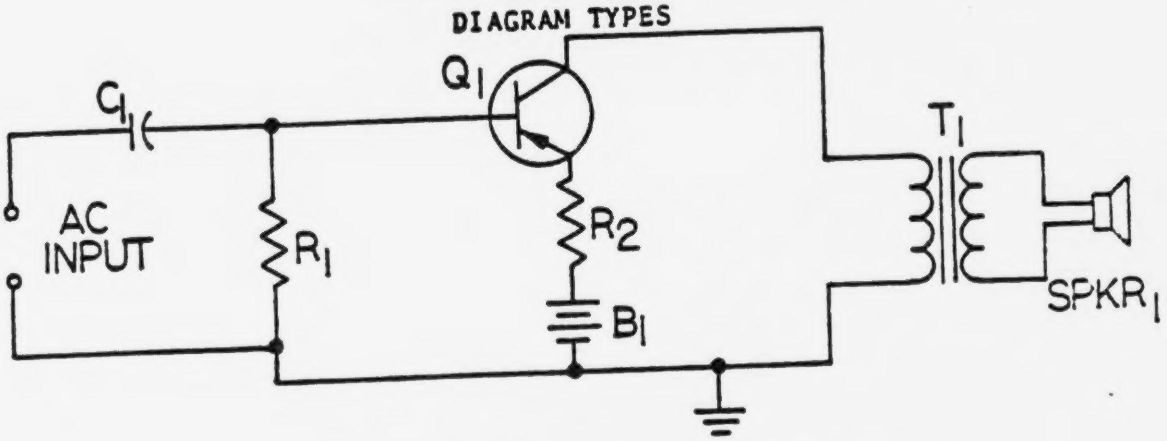
Name: ______________________

Date: ______________________

Period: ______________________

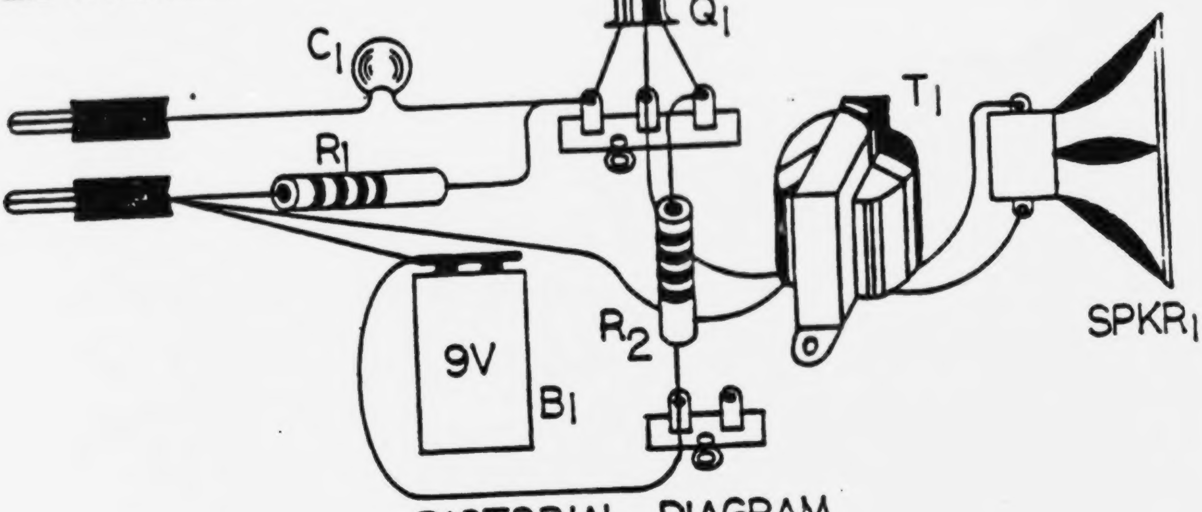
INFORMATIONAL HANDOUT

DIAGRAM TYPES



SCHEMATIC DIAGRAM

The schematic diagram is the most important diagram used by electronics personnel because it provides a convenient way of tracing circuit operation and signal flow. On this diagram the components are represented by graphic symbols, and the connecting lines indicate wires. The symbols and associated lines show how the components of a circuit are connected and the relationships among the various parts. The symbols are arranged so that the diagram can be "read" from left to right. Component symbols are assigned a letter designation for parts identification. Whenever possible connecting lines should be drawn either horizontally or vertically. The numerical values of components are often indicated directly on the diagram. Unlike the pictorial diagram, the schematic does not show the location of components or wires on the chassis; it also does not show wiring devices such as lugs, sockets, and terminals.



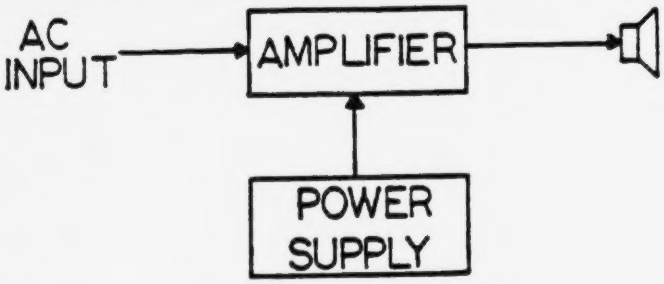
PICTORIAL DIAGRAM

Name: ____________________

Date: ____________________

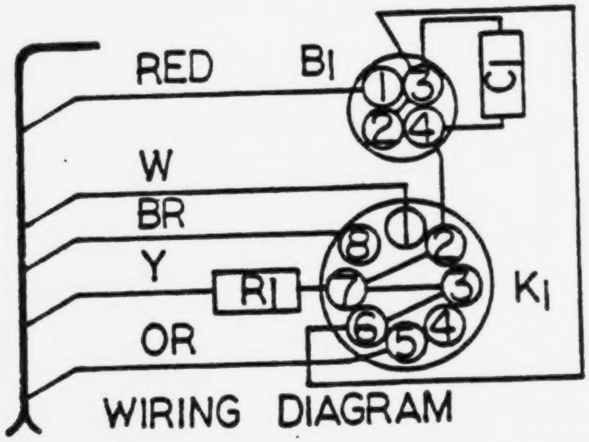
Period: ____________________

The pictorial diagram is easy to read and interpret. The drawing shows the circuit components, their location on the chassis or panel, and how they are connected together. The diagram is usually drawn to scale, and wire connections are drawn with as little cross-over as possible. Components are generally identified by their reference designation. Pictorial diagrams are widely used in assembly line production work, maintenance activities, and do-it-yourself kits.



BLOCK DIAGRAM

The block diagram is used to show the relationship between various stages in a system. It indicates the path of signal flow through a circuit or the operational sequence that is followed by the circuit. The blocks, which represent a circuit or stage, are most often drawn as squares or rectangles, and joined by single lines. Arrowheads at the ends of the lines indicate the direction of signal flow. Each stage (block) is labeled with its function; as a general rule the stage operation is printed within the block. This diagram does not give any information on components used within the stages, or wiring connections. One use for block diagrams is as a first step in design or engineering of a system. The basic stages and signal flows are determined in block form. From there, a schematic diagram of each stage and interconnection can be developed.



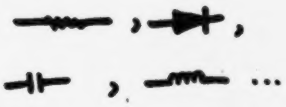
WIRING DIAGRAM

The wiring diagram is used to show wiring connections in a simplified manner. The diagram can show circuit components in a pictorial manner, and is primarily a connecting and visual troubleshooting aid. Wires are labeled by color for ease in identification. Wiring diagrams are also applicable to wire harness layout and connection diagrams.

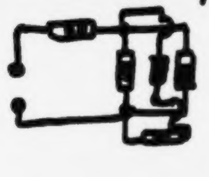
GRAPHIC ILLUSTRATIONS

block diagram : biểu đồ chỉ từng nhóm kết hợp.

graphic symbol # schematic symbol (biểu đồ hình vẽ) dấu hiệu đại diện cho components trên đồ biểu



pictorial diagram : biểu đồ vẽ hình ảnh trên hiện, Khung xe nói rõ vị trí của component và các nối dây.



Reference designation : Sự chỉ danh tham chiếu. R_3 . R_a ...

stage : giai tầng

subscripts : chỉ số dư phần

R_3 , R_4

system : hệ thống. một đơn vị điện tổng quát (bao quát) của các tầng hỗ tương

comprise : bao quát.

interacting : hỗ tương qua lại.

wiring diagram : biểu đồ dây điện. (biểu đồ chỉ sự đi dây điện).

associated : liên kết, kết hợp.

arranged : xếp đặt.

interpret : giải thích, thông dịch.

maintenance : bảo trì

Kits : tập tài liệu.

Sequence : chạy theo nhau

arrowheads : dấu mũi tên

visual : trông thấy được

applicable : ứng dụng

harness : bó dây (nhiều dây điện hay dây cáp bó lại)

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繪圖書寫解說 (GRAPHIC ILLUSTRATION

技術語彙

abbreviation：简称，缩写.

shortened：简短.

representative：代表.

block diagram：方块圖，简图.

functional：運作，操作，運用

component：组件，構成要件.

connection：接連.

graphic symbol：图繪符號.

depict：描出.

schematic：概要图式的.

letter identification：文字識别

numerical value：數字值.

pictorial diagram：用图畫表示的图表.

reference designation：参考番號.

simplified：简單化]的.

structure：结構.

physical：物性，实物的.

layout：图表.

stage：程度，階段，級，

performs：完成，实行.

subscripts：写在字右下角底的文字或數字.

filament：燈丝.

XMFR：= transformer 变压器

equivalent：等效的，等值的.

zener：齊納，(人名，他分析出绝缘体的电压擊穿.)

regurated：被調正的.

taped inductor：带绕电感应器

LIII-U5-16

antenna = 天线 (ANT).

aerial : 架空的, 天线的.

loop = 回路, 環, 匝. 環形天线.

tunnel diode = 隧道二極管

batteries = 电池

capacitors = 电容器

electrolytic = 电解

ganged : 同軸, 联动的.

conductor = 導线

crystal = 晶体

connectors : 連接器.

phone jack : 电話机接頭.

coaxial : 同軸

receptacle = 插座.

light emmitting diode : 能放射光的
二極管 (LED)

triac : 三重軸 (一种没有陽極.陰極
之分的双向矽可控整流器)

rectifier = 整流器.

headset : 耳机

inductor = 电感应器.

incandescent = 发白热光的.

logic : 邏輯.

gate = 闸

exclusive OR 或 XOR 互斥性.

AND = 及. AND gate = 及闸

OR = 或 OR gate = 或闸

NOT = 反 NOT gate = 反闸

NOR 或 Not OR = 不是 OR.

NAND 或 Not AND = 不是 AND

polarity = 極性.

photoelectric cells = 光电池光电管.
光电元件.

linear integrated circuit = 直线性集
成电路

thermistor：热变电阻器，热敏电阻

thermocouple：热电隅，温差电隅

FET = field effect transistor
塲效应晶体管.

MOS = metal-oxide-semiconductor
金属一氧化物一半导体

UJT = unijunction transistor
單结晶体管.

grid：栅(極)，網.

triode：三極管

tetrode：四極管

pentode：五極管

vacuum tubes：真空管

convenient：方便，便利.

tracing circuit：跟踪电路，故障寻找
检驗电路，

maintenance：保養，维護.

arrowhead：箭頭

ELECTRONIC CURRICULUM

VOCATIONAL TRAINING I N PLAN # ______ Housewiring

Teaching Materials Source ______________________________

Chapter ______________, pages ______________

Lab Manual pages ______________

Additional Instructor Materials ______________________________

Main concepts student will learn:

The students will be able to:

1. state the specific function of a service connection and describe in detail what is being measured by a kilowatt-hour meter.
2. identify and differentiate between a variety of basic electrical wiring components and materials including duplex receptacle, switch, conduit, sheathed cable, etc., which may be encountered when studying the composition of home electrical circuits.
3. demonstrate simple wiring skills and recite the technical procedures necessary to accomplish the replacement of a fuse, resetting of a circuit breaker, and/or the replacing of an electrical switch or outlet.

Length of Lesson

1 day

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Technical Vocabulary

see
Glossary

Related General Vocabulary

see
Glossary

Materials and Notes

Teaching Activity

1. This unit is far more effective if the students have an opportunity to interact with the actual materials and wiring apparatus. if a commercially produced wiring demonstrator is not available it is fairly easy to create a usable instructional device to further facilitate this unit of instruction. Work with the wood and drafting instructors and design a portable wall demonstrator that can be rotated into different labs as needed to illustrate various principles in house construction, architectual design, and/or residential wiring. The wall trainer should be able to accomodate several students on an individualized paired basis, and it should realistically simulate a wall and partial ceiling section. Additional electrical parts and materials such as; switches, lights, watt-hour meter, romex, signalling devices, fixtures, etc. may be mounted as desired to accomodate wiring experiments.

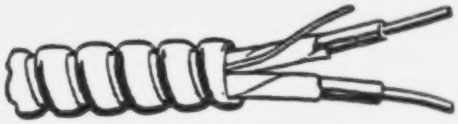
HOUSEWIRING

Name: ______________________

Date: ______________________

Period: ______________________

TECHNICAL GLOSSARY

AC PLUG:	A two or three prong plug attached to one end of a line cord. The AC plug will mate with the wall outlet or recepticle to provide a contact with the 120V source.
APPLIANCE CIRCUIT:	A house wiring circuit, generally found in the kitchen and laundry areas, which is designed to supply the power required to operate large appliances such as a dish washer, refrigerator, microwave oven, washing machine, etc. The circuit is probably designed for a 20 ampere current flow, requiring at least 12 gauge wire.
ARMORED CABLE:	A semi-flexible, metallic sheathed cable used for interior wiring. Armored cable is generally used when wiring 220V circuits, such as electric ranges and clothes drier circuits. 
BOXES:	A steel or nonmetallic box attached to a stud or inner wall, and used to house switches, outlets, or lighting fixtures, and their connecting wires.
BRANCH CIRCUIT:	A parallel circuit, which supplies current to various lead devices from a single voltage source. Outlet circuits are generally connected as branch circuits, each branch being protected by a fuse or circuit breaker.
COLOR CODING (WIRE):	A conductor identification system designed to code wire function by using various colors. Wires of different colors are not usually connected together. For residential application, white is used to indicate neutral, black denotes the hot wire, and green represents earth ground.
CONDUIT:	Thin walled metal tubing, usually 3/4 inch or 1 inch in diameter, used to house electrical conductors or wires.
CONSERVATION:	The process of saving or limiting the use of a resource, such as electrical energy.
DISTRIBUTION PANEL:	A panel or box, usually found directly below the kilowatt-hour meter, which contains the main switch used to turn off the electricity to the home, and the various fuses or circuit breakers used to protect the various house circuits. All wiring for each branch circuit begins at the distribution panel.
ELECTRIC SERVICE PANEL:	The main panel or cabinet through which electric power is brought into the home and distributed to the various branch circuits. The service panel generally contains the kilowatt-hour meter, the main power disconnect, and the circuit breakers or fuses for each branch circuit.

LAB EXPERIMENT

UNIT: Housewiring

OBJECTIVE: To demonstrate wiring skills and accomplish the wiring of an electrical switch, convenience outlet, and a lamp.

MATERIAL:

1 convenience outlet box

1 duplex receptacle

1 ceiling box

1 light socket

1 two wire cable with ground #14 or #12 - approx. 24" long

2 - 3 way switch

PROCEDURES:

Study all appropriate materials from your information sheets. Follow all instructions for wire color codes and techniques for attaching wire to the terminals. When you have your project completed, bring it and this lab sheet up to the instructor for grade.

PROJECT ONE:

Wire up a wall switch to control a light.

Instructor ______________________________ Grade ______________

PROJECT TWO:

Wire up a switch to control a duplex receptacle.

Instructor ______________________________ Grade ______________

PROJECT THREE:

Wire up two three way switches to control a light from either switch.

Instructor ______________________ Grade _______ Total Grade ______

UNIT EXAM

IMPORTANT:

Indicate your responses on teh answer sheet only. Fill in the box corresponding to the correct answer to each question. There is only one correct answer for each question.

1. The amount of electrical energy consumed in your home is measured by a kilohour-watt meter. (T - F)

2. The individual dials of a kilowatt-hur meter all have the same kwh value. (T - F)

3. The basic energy unit upon which electric companies base their customers bills, is the watt-hour. (T - F)

4. The kilowatt-hour meter is connected between the entrance head and the distribution panel in such a way that all energy consumed can be accurately measured. (T - F)

5. A branch circuit and a series circuit are the same. (T - F)

6. The bare copper wire found in house wiring systems is always a "hot" wire. (T - F)

7. Normal home electric service is designed to supply both 120 volts and 240 volts. (T - F)

8. The advantage of a fuse, is that it can be easily reset by moving a switch lever. (T - F)

9. The standard color coding for the neutral wire used in house wiring, is white. (T - F)

10. When installing a duplex outlet, the brass attachment screw is connected to the "hot" or black wire. (T - F)

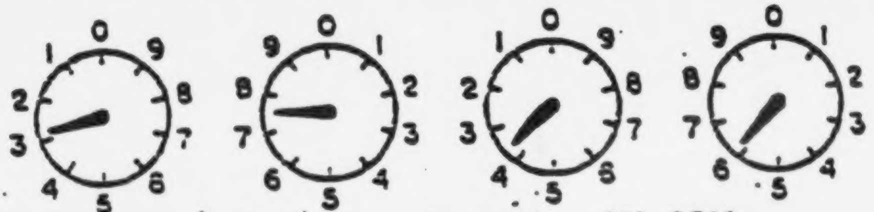
11. A circuit overload will generally not cause a circuit breaker to trip. (T - F)

12. It is perfectly safe to replace a wall switch or duplex outlet without turning off the main power, if you work carefully. (T - F)

13. Each branch circuit in the home should contain either a fuse or a circuit breaker to prevent short circuit conditions. (T - F)

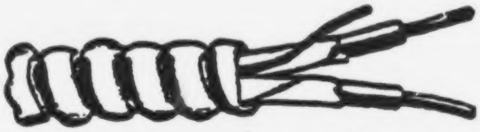
14. Overloaded glass cartridge fuses can be identified by an open or burned fuse link. (T - F)

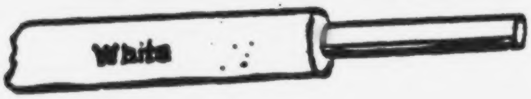
15. What is the reading on the kilowatt-hour meter?

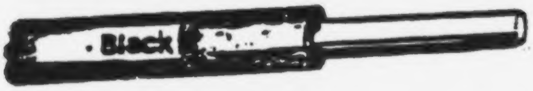


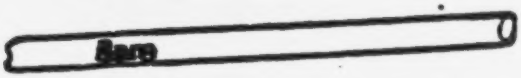
(A) 6372, (B) 2736, (C) 3746, (D) 2746.

Identify the following residential wiring items by matching the sketch with the item description. On your answer sheet record only the letter of the identifying term.

16. 

17. 

18. 

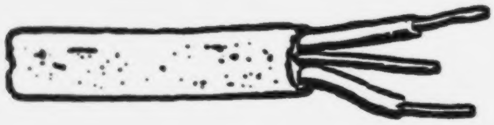
19. 

20.

E. Hot wire
F. Cover plate
G. Wall switch
H. Armored cable
I. Lamp socket
J. Crimp connector
K. Distribution panel
L. Conduit
M. Neutral wire
N. Twist Connector (wire nut)

O. AC plug
P. Receptacle (110V)
Q. Entrance head
R. Box
S. Nonmetallic sheathed cable
T. Ground wire
U. Kilowatt-hour meter
V. Fixture box

21.



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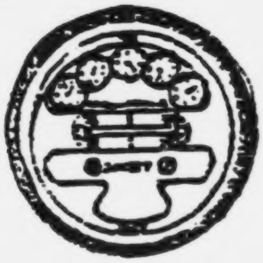

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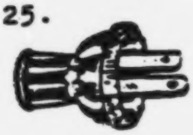

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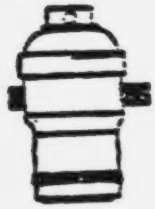

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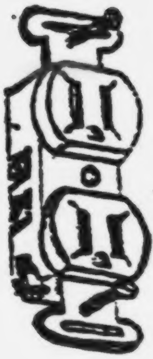

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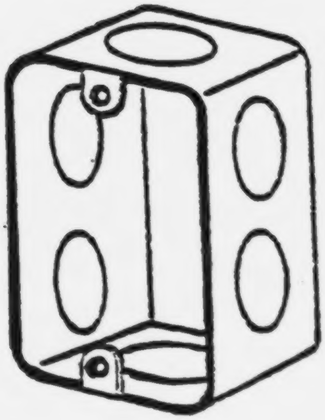

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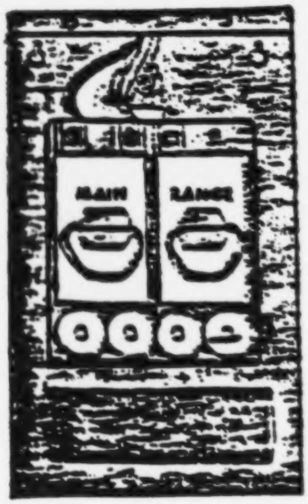
30.



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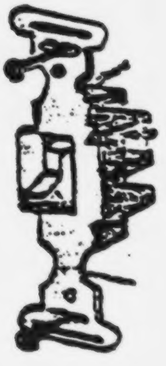

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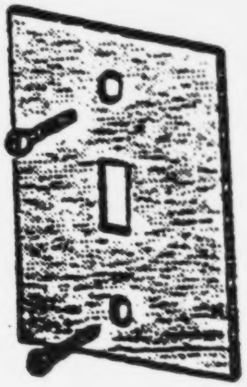


House wiring

AC plug	Phích cắm điện AC.
Prong	răng chĩa ra (của phích)
line cord	loại dây điện lớn (thuộc điện AC)
mate	làm bạn (giữa phích và ổ cắm điện).
Wall outlet	ổ cắm điện tường
Recepticle	ổ cắm điện
Appliance circuit	mạch điện nhà (Cung cấp điện cho đồ dùng điện trong nhà)
laundry area	khu vực giặt rửa (gồm máy giặt, máy sấy).
dishwasher	máy rửa chén đĩa.
Rifrigerator	tủ lạnh.
microwave oven	máy hấp; lò nướng loại lớn.
washing machine	máy giặt.
armored cable	dây cáp có vỏ bọc.
flexible	mềm (uốn được)
matallic (a)	Kim loại.
Streated	bao bọc
cable	dây thép; ruột dây điện AC.
invertor wiring	dây dẫn điện
clothes drier	máy sấy quần áo.
Box	hộp đựng
stud	đinh đóng tường; đinh (gắn hộp)
lighting fixture	chụp đèn.
color coding (wire)	hệ thống màu của dây điện.
Identification	sự nhận dạng;
function	chức phận; nhiệm vụ.
Recidential	cư trú; chỗ ở.
indicate	chỉ định.
denote	biểu thị; chỉ rõ
represent	đại diện
white	trắng (chỉ trung tính: neutral)
black	đen (chỉ dây nóng: hotwire)
green	xanh dương (chỉ dây đất Groundwire).

conduit : ống dẫn dây điện.

conservation : sự giữ lại; sự duy trì; sự giới hạn (tiết kiệm).

saving : tiết kiệm.

resourse : tài nguyên.

distribution panel : hộp phân phối điện.

panel = box : hộp.

Kilowatt hour meter : đồng hồ đo công suất điện tiêu thụ tính trên đơn vị Kilowatt giờ.

electric service panel : hộp cung cấp điện (giống và đồng nghĩa như distribution panel).

cabinet : bình chứa. (điều chỉnh).

distributed : phân phối; phân phát.

disconnect : tách ra.

general purpose circuit : mạch điện thông thường.

except : ngoại trừ; trừ ra.

abnormal situation : tình trạng bất thường; vị thế bất thường.

monitor : theo dõi

record : thu

lamp socket : chấu đèn; đế đèn; chân đèn.

National electrical code : mã số về điện của 1 quốc gia. (qui ước về điện thuộc quốc gia)

concent : sự chứa đựng; cổ.

arising : phát sinh

hazard = Random : ngẫu nhiên; tình cờ.

interrupted : đình chỉ.

Nonmetallic : không kim loại.

romex : âm đất.

duplex : gấp đôi.

purchase : mua; đặt mua.

solderless connector = wire nut = twist connector : mút để nối dây điện.

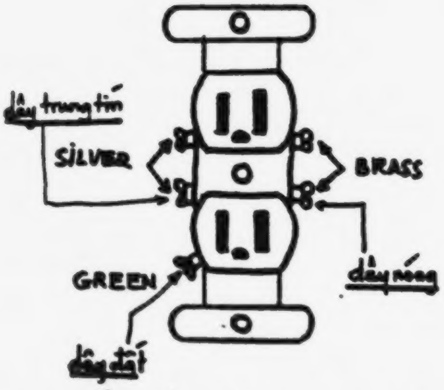
firmly : vững chắc.

bare : trần.

diameter : đường kính.

2. HW

purpose	mục đích.
entrance head	điểm (đầu) điện nhập.
support cable	Kẹp giữ ống dây dẫn dây điện.
main power shut-off	năng lực chính được nhập.
via	đi qua
installation	sự thiết lập.
extend	phát ra.
referred to as	biết như là; coi như là.
local	địa phương.
consumed	tiêu thụ.
consumption	sự tiêu thụ.
consumer	Khách hàng.
+ numerial Readout	đọc bằng số.
sensitive	nhạy bén
adjacent	tiếp cận, kế tiếp.
sequency	Kết quả; liên hợp.
tips	sự mách nước.
reference	liên quan
guide	hướng dẫn.
conform	xứng hợp; tương xứng.
wear	mang; mặc.
Rubber	cao su.
exactly	một cách chính xác.
immediately	ngay lập tức.
Plug fuse	cầu chì loại (phích)
cartridge	cầu chì loại ống.
label	nhãn hiệu
shut	ngắt; "cúp".
disabled	bị hư hỏng.
plugged in	được cắm vào.
enclosure	hàng rào.
tripped	đẩy; bấm; bật.
cover plate	tấm che trên mặt một công tắc
Remount	đặt lại, dời lại.
Restore	đặt lại; đậy lại.
convenience outlets	ổ cắm điện tiện dụng.
critical	nguy cấp.



ổ cắm điện nhà "Kẹp".

3. HW.

LII-U19-7,-8

室内布线(配线) (HOUSE WIRING)

技術語彙

plug：插頭，塞子，火星塞.

prong：叉状物，(叉子等的)尖頭

mate：配合，配對.

recepticle：插座，插孔.

appliance circuit：設備线路.

armored cable：外装电纜.

electric range：电竈，电氣爐灶.

stud：[建築上] 间柱

outlet：出路，引出线，电源插座.

lighting fixtures：照明器材.

branch circuit：分支电路

breaker：闸阀，断电器

color coding：顏色標記，色碼.

denote：表示.

conduit：導管，管道.

conservation：守恒，保存，如 conservation of energy 能量不滅.

distribution panel：配电盤.

electric power：电力，电功率.

grounded：已接地线，地线.

grounding wire：地线.

hot wire：热线，带电之电线.

individual：單個的.

kilowatt hour：千瓦小時 (KWH)

monitor：監聽，追蹤，纠察.

lamp socket：燈座，燈泡插座.

line cord：電线(含两或三條多股电线)

hazards arising：產生危險

nonmatallic：非金属的.

sheathed cable：有護皮的电纜

recepticle：插孔、插座.

duplex：双路的，双联的.

service drop：架空進户线，架空引入线.

three-way switch：三路開關.

consumed：耗，消耗.

pointer：指针，指示器.

overloads：过載，过負荷.

cartidge：熔丝盒.

cartidge fuse：管形熔丝，熔丝管.

wear-out：疲劳，磨損.

bare：裸的

loop：圈，扣環，環线，彎曲线.

interrupted：断開的，中断的，断續的.

convenience outlets：便利的插座.

ELECTRONI CURRICULUM
VOCATIONAL TRAINING SON PLAN #VII
ELECTRICAL ENERGY AND POWER

Teaching Materials Source ____________________
Chapter __________, pages __________
Lab Manual pages __________
Additional Instructor Materials ____________________

Main concepts student will learn:

1. to distinguish between the following units of measurement and/or terms; work, joule, watt, power and energy.
2. recite and apply both Ohm's and Watt's law as requested when solving or evaluating circuits.
3. summarize and discuss power loss as I^2R loss and explain its relationship to heat or power dissipation.
4. differentiatae and compare power rating data of appliances or devices, and solve typical electric company bill based on electrical consumption, measurement, and charge rate for electricity.

Technical Vocabulary

see Glossary

Related General Vocabulary

see Glossary

Teaching Activity

see attached

Length of Lesson

2 - 3 days

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Materials and Notes

1. Instructor demonstrates the procedure necessary in order to read and compute power used. Draw a set of dials (without needles) to simulate a kilowatt-hour Meter, then adjust needles to indicate a reading and obtain student response. Drawings can be applied to blackboard, cardboard, acetate sheet or flip chart.
2. Instructor can assemble a variety of different size incandescent lamps from 10 watts to 1000 watts in ascending order on a predrilled demonstration board. This type of aid will allow students to vividly see the contrast in size and the relationship to power rating.
3. When presenting materials on power and energy it is quite simple to expand discussions, experiments, and demonstrations to include housewiring and replacement of fuses. A wall frame or section in minature can be constructed with appropriate electrical boxes and switches mounted, then have

TEACHING ACTIVITIES

1. Distinguish to the class between the concept of useful power versus wasted power and their relationship to this unit. Have students provide examples to illustrate their understanding of the concept. Impress students with the idea that power which is wasted is referred to as dissipated power.

2. The key to this unit is instructor organization of terms presented, be mindful to take care of technical word accuracy. Many authors, educators, and instructors are vague when introducing power and energy because this topic traditionally was based on the premise of separate units of measurement for indicating such things as heat, mechanical and light energy. This technique encourages erroneous interpretations or at best difficulty in comprehension.

3. In addition to basic knowledge and formulas related to power, illustrate the method in which electricity is generated and distributed for general consumer usage. Many local power companies supply to educational institutions free of charge the following: films, filmstrips, tapes, pamphlets, books, ditto masters, and other kinds of media materials.

4. Do not overkill the concept of energy conservation but develop several activities which might allow thought provoking discussions. Consider having the class answer an essay question on the topic of ways to reduce the total energy used at home or have students paste pictures of appliances on cards and indicate their wattage consumption. These kinds of activities provide an opportunity to discuss the impact of this critical social issue upon their personal life.

Name: ____________________

Date: ____________________

Period: ____________________

ELECTRICAL ENERGY & POWER

TECHNICAL GLOSSARY

CIRCUIT BREAKER:	A current sensing device which automatically opens a circuit when current exceeds a set value. A circuit breaker may be reset after it trips. The circuit breaker, like a fuse, is used to protect a circuit against excess current. Letter symbol: CB Symbol:
COULOMB:	The magnitude or measure of electrical charge, one coulomb is equal to the combined charge of 6,280,000,000,000,000,000 electrons (6.28×10^{18}).
DECIBEL:	A measurement of the ratio of one power to another power. Decibel ratings are based upon logarithmic increases or decreases. Abbrev. dB
EFFICIENCY:	A percent measurement of how effective a device is in using electric power. A machine which has an output power equal to its input power is said to be 100% efficient; but this as you know is impossible. Formula: $\text{Efficiency} = \frac{\text{OUTPUT (WATTS)}}{\text{INPUT (WATTS)}} \times 100$
ENERGY:	The capacity or ability to do work. Energy is a force (electrical, mechanical, kinetic, etc.) which can be used to do work.
ENERGY CONSUMPTION:	The rate of using energy. Electrical energy consumption is the product of power and time. A common unit for measuring energy consumption in the home is the kilowatt-hour
FUSE:	A device used to protect a circuit against excess current. The fuse utilizes a metal link which melts and opens the circuit when the current exceeds a set value. Letter symbol: F Symbol: ∽
HEAT SINK:	A metallic device, usually aluminum, used to carry heat away from a component. Heat sinks are commonly found on transistors, SCR'S, and other semiconductor devices which produce heat during operation.
HORSEPOWER:	A measurement of mechanical power equal to the product of work in footpounds and time in seconds. Electrical power and mechanical power can be compared by using the conversion 746 watts = 1HP.
I^2R HEAT:	This term describes the heat produced by a circuit when current flows through a resistance. Also referred to as I^2R loss or copper loss.

Name: ____________________

JOULE:	The basic unit of electrical energy and/or work.
KILOWATT-HOUR:	The basic unit of measurement for electrical energy consumption for both home and industry. Equivalent to 1000 watts of power used in one hour. Letter symbol: kwh
KILOWATT-HOUR METER:	A meter used to measure electrical energy consumption in kilowatt-hours, and which is monitored by the power company.
POWER:	A measure of the time rate of doing work or using electrical energy, $\text{power} = \frac{\text{work}}{\text{time}}$. Electrical power is frequently expressed as the product of voltage and current, and is measured in watts. (See Watt's Law) Letter symbol: P.
POWER DISSIPATION:	The power wasted, in an electrical circuit, due to heat or I^2R losses.
WATT:	The basic unit of measurement for electrical power. One watt of power is provided when one ampere of current flows through a load with a one volt drop across its terminals. Letter symbol: W.
WATTAGE RATING:	A measure, in watts, of the maximum power a device consumes or dissipates, and frequently referred to as the power rating.
WATT'S LAW:	An electrical law which expresses the relationship between power, voltage, and current. It states that power (in watts) is equal to voltage (in volts) times current (in amperes). Mathematically this is expressed as $P = E \times I$.
WORK:	Electrical work is considered as power x time. The basic unit for work is the joule.

Test Number ______

LIII-U7

UNIT EXAM

ELECTRICAL ENERGY AND POWER

IMPORTANT-
Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. The ability of a resistor to dissipate heat depends mainly upon its physical size. (T-F)

2. To find power of a given circuit P = I x E or P = E x I. (T-F)

3. Power is measured in the basic unit of whats. (T-F)

4. The term power refers to the rate of doing work or using energy. (T-F)

5. Electrical energy is an invisible force which can be harnessed to do work. (T-F)

6. Electrical work and power have a similar basic unit which is the joule. (T-F)

7. The comparison of one power level to another power level is often expressed in decibels. (T-F)

8. A milliwatt is equivalent to one millionths of a watt. (T-F)

9. I^2R heat refers to the heat produced in an electric circuit when resistance flows by a current. (T-F)

10. One way that an electrical circuit can do work, is by converting the force of moving electrons or protons into some other form of energy, such as heat, sound, light, or magnetism. (T-F)

11. The common energy unit that most electric companies base customers bills on is the watt-hour. (T-F)

12. Power is directly proportional to current. That is, as current increases in a circuit (resistance held constant) power also increases. (T-F)

13. The greater both voltage and current, and more energy will be delivered to a load during a given time. (T-F)

14. Watt's Law explains the relationship between voltage, power, and current. (T-F)

15. The individual dials of a kilowatt-hour meter all have the same kwh value. (T-F)

16. In an electric circuit where the source voltage is 400 volts and the total circuit current is 1.5 amperes, how much power is being used? (A) 100 watts. (B) 400 watts. (C) 600 watts. (D) 202 watts.

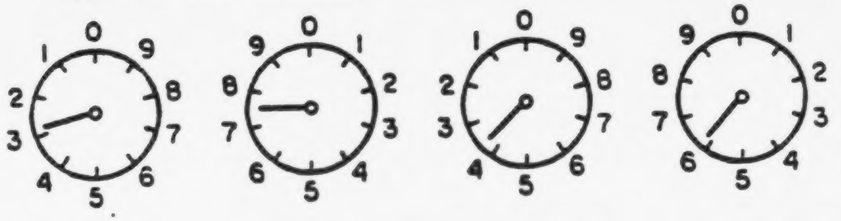
17. Of the following sources, which can provide the most power? (A) A 30 volt source capable of supplying 5 amperes. (B) A 100 volt source capable of supplying 2 amperes. (C) A 12 volt source capable of supplying 10 amperes. (D) A 30 volt source capable of supplying 10 amperes.

18. The basic unit of measure for electric power is the (A) ampere. (B) watt. (C) volt. (D) ohm.

19. When a resistor has a 20 watt rating, this means that it (A) always dissipates exactly 20 watts of power. (B) always provides 20 watts of power. (C) should be used in a circuit where it will dissipate more than 20 watts of power. (D) can safely dissipate 20 watts, of power or less.

20. In a circuit consisting of three resistors, the total power being dissipated is (A) less than the power being dissipated by any one resistor. (B) equal to the sum of the powers dissipated in all three resistors. (C) divided equally among the resistors. (D) termined by multiplying the source voltage by the current through one of the resistors.

21. What is the reading on the kilowatt-hour meter?



A) 6372
B) 2736
C) 3746
D) 2746

22. Find power if E = 50V and I = 2A. P = ________ watts. (A) 100W (B) 25W (C) .04W (D) 500W

23. Find power if E = 12V and R = 48 ohms. P = ________ watts. (A) 4W (B) .25W (C) 3W (D) 576W

24. Find power if I = 2A and R = 150 ohms. P = ________ watts. (A) 300W (B) 600W (C) 75W (D) 37.5W

25. Find voltage if P = 100W and I = 4A E = ________ volts. (A) .04V (B) 400V (C) 104V (D) 25V

26. Find current if E = 120V and P = 600W I = ________ amperes. (A) .2A (B) 5A (C) 720A (D) 60A

27. How much current is drawn by a circuit which dissipates 4800 watts of power when the source voltage is 120 volts? (A) 20 amperes. (B) 40 amperes. (C) 400 amperes. (D) 200 amperes.

28. How much power is dissipated by a circuit that has a 75-volt source and a current flow of 5A? (A) 375W (B) 3.75W (C) 0.375W (D) 37.5W

29. An electric iron operating from a 120 volt power source draws or uses 4 amperes. How much power does it consume? (A) 30 watts. (B) 480 watts. (C) .033 watts. (D) 48 watts.

30. What is the wattage rating of a TV receiver, which is connected to 100 volts and drawing 3.5 amperes? (A) 35 watts. (B) 3.50 watts. (C) .350 watts. (D) 350 watts.

ELECTRICAL ENERGY & POWER

circuit breaker: cái ngắt điện.

Sensing : cảm ứng

sens : cảm thấy.

magnitude : cỡ, độ lớn

Reset , đặt lại

Coulomb : đơn vị của điện lượng Q

$1coulomb = 628 \times 10^{18} e$

Decibel : đơn vị dùng để diễn tả sự tăng hoặc giảm của công suất.

(Pout / Pin)

$$DB = 10 \log_{10} \frac{Pout}{Pin}.$$

effeciency : hiệu suất

$$\% eff = \frac{out(P)}{In(P)} x100.$$

energy : năng lực

Kinetic : động lực học

electrical : điện lực học

chematical : cơ học.

energy consumption : sự tiêu thụ năng lực.

aluminum: nhôm.

carry : mang, chuyển.

Joule : đơn vị của năng lực hoặc công.

monitored: được theo dõi.

power dissipation: sự tiêu hao công suất.

wasted : tiêu phí, tiêu hao (mất đi bởi nóng)

crossword: chữ thập.

fit : ráp, lắp.

clues : việc phức tạp, rắc rối.

Transmission lines : dây dẫn điện cao thế

Substation: trạm biến thế.

Distribution lines: đường dây dẫn điện phân phối

Concern : quan tâm.

Obviously : hiển nhiên.

SCORE:

GRADE:

Name: ______________

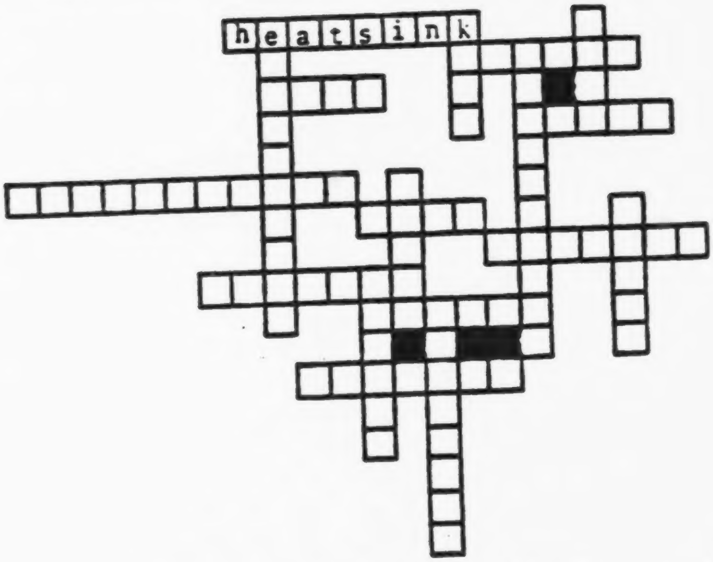
Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - CROSSWORD PUZZLE

Below are clues to electrical terms. To solve the puzzle find the terms, and fit them into the proper places in the diagram. A key word has been provided on the puzzle as a starting point from which other terms can be added or branched as necessary.



1. One ________ is equal to the combined charge of 6,280,000,000,000,000,000.
2. Abbreviated dB. ________
3. Power lost due to heat. Power ________.
4. $\frac{\text{OUTPUT}}{\text{INPUT}}$ X 100 = ____________.
5. Some kind of force that can be used to do work.________
6. Another name for a mathematical formula. ____________
7. Something used to solve for an unknown value provided all necessary data is available.____________

1.

2.

3.

4.

5.

6.

7.

Name: ____________________

Date: ____________________

Period: ____________________

8. Protects a circuit against excess current. ______________

9. 746 watts = 1 ____________________.

10. Heat produced when current flows through a resistance. ____________________

11. The basic unit of electrical energy. __________

12. Prefix meaning 1,000. ______________

13. The pointer on a meter. ______________

14. ______________ = voltage x current.

15. A mathematical relationship comparing one number to another. ____________________

16. Basic unit of measurement for electrical power. ______________

17. Power x Time = ____________________.

8.

9.

10.

11.

12.

13.

14.

15.

16.

17.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

WATT'S LAW

1. Power equals voltage multiplied by the ________.

2. One ________ is equal to one thousand watts.

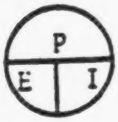
3. The three commonly used power formulas are A) P = ________ , B) I = ________ , and C) E = ________

4. The ________ is the electrical unit of power.

5. What is the power dissipation of a 40 ohm resistor with 3 amps flowing through it? Hint: $P = I^2 \times R$.

1. ☐
2. ☐
3A. ☐
3B. ☐
3C. ☐
4. ☐
5. ☐

Using the Watt's Law magic circle solve the following power problems.



6. E = 100V, I = 2A, P = ________ watts

7. E = 150V, I = .5A, P = ________ watts

8. P = 400W, E = 80V, I = ________ amperes

9. P = 100W, I = 2.5A, E = ________ volts

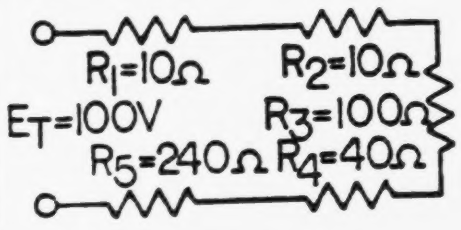
10. P = 1800W, I = 4A, E = ________ volts

6. ☐
7. ☐
8. ☐
9. ☐
10. ☐

Name: ____________________

Date: ____________________

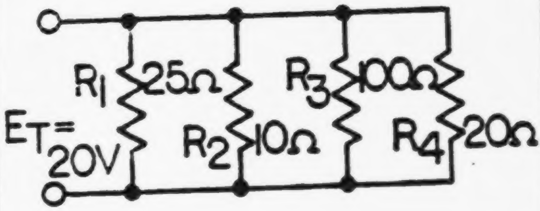
Period: ____________________


$R_1=10\Omega$
$R_2=10\Omega$
$E_T=100V$
$R_3=100\Omega$
$R_5=240\Omega$
$R_4=40\Omega$

11. Find I_T
12. Find P_T
13. Find P_{R_1}
14. Find P_{R_2}
15. Find P_{R_3}
16. Find P_{R_4}
17. Find P_{R_5}

Show work

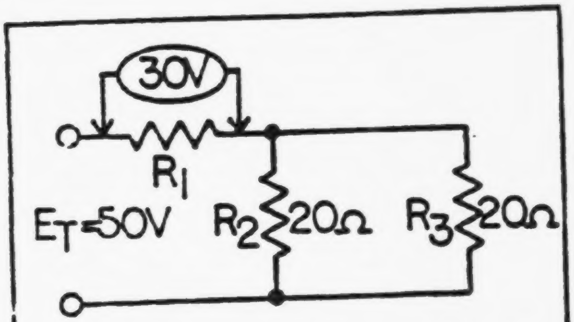
11.
12.
13.
14.
15.
16.
17.


R_1
25Ω
$E_T=20V$
R_2
10Ω
R_3
100Ω
R_4
20Ω

18. Find R_T
19. Find I_T
20. Find P_{R_1}
21. Find P_{R_2}
22. Find P_{R_3}
23. Find P_{R_4}
24. Find P_T

Show work

18.
19.
20.
21.
22.
23.
24.


30V
R_1
$E_T=50V$
R_2
20Ω
R_3
20Ω

25. Find I_T
26. Find P_{R_2}
27. Find P_{R_3}
28. Find P_{R_1}
29. Find P_T
30. Find R_T

Show work

25.
26.
27.
28.
29.
30.

Name: ______________

Date: ______________

Period: ______________

SCORE:

GRADE:

WORKSHEET

POWER RATINGS AND COST ANALYSIS

Energy is the capacity for doing work. Household appliances and entertainment systems consume electrical energy and in turn perform work. Knowing how much energy a device uses can assist in identifying where energy is wasted and conservation efforts could apply.

Using the list below place a check mark (✓) beside each appliance you or your family own. Then, review the list, and mark a star (*) by the 10 items you use most frequently.

___ Air Cleaner
___ Air Conditioner (room)
___ Black and White TV
___ Blender
___ Blow Dryer
___ Broiler
___ Carving Knife
___ Clock
___ Clock Radio
___ Clothes Dryer
___ Coffee Maker
___ Color TV
___ Crock Pot
___ Curling Iron
___ Dehumidifier
___ Deep Fryer
___ Dish Washer
___ Drill (portable)
___ Egg Cooker
___ Electric Blanket
___ Electric Can Opener
___ Electric Typewriter
___ Electronic TV Games
___ Fan
___ Floor Polisher
___ Food Processor
___ Freezer
___ Fry Pan
___ Hair Dryer
___ Heating Pad
___ Heat Lamp
___ Hot Curlers
___ Hot Plate

___ Humidifier
___ Ice Cream Maker
___ Iron
___ Lamps and Lighting
___ Meat Slicer
___ Mixer
___ Oven, Microwave
___ Pop Corn Popper
___ Portable Heater
___ Projector
___ Radio
___ Radio/Record Player (stereo)
___ Range with oven
___ Range with self-cleaning oven
___ Refrigerator
___ Roaster
___ Sandwich Grill
___ Sewing Machine
___ Shaver
___ Sun Lamp
___ Table Saw
___ Tape Recorder
___ Toaster
___ Toaster Oven
___ Tooth Brush
___ Trash Compactor
___ Vacuum Cleaner
___ Waffle Iron
___ Washing Machine
___ Waste Disposer
___ Water Heater

Name: ____________

SCORE:

GRADE:

Date: ____________

Period: ____________

WORKSHEET

ELECTRICAL ENERGY CONSUMPTION CHART

This chart indicates the average wattage, average hours of use per year, and the estimated kwh's of energy used by each appliance per year. The calculations have been completed for you, but it will be necessary to recall the method used to compute kilowatt-hours.

NOTE:

$$\text{kwh} = \frac{\text{Wattage x Hours of use}}{1000}$$

Locate and mark the starred (*) items, from page one, on the chart below.

▲ ENERGY CONSUMPTION CHART ▲

Item	Average Wattage	Average Hours Per Year	Est. kwh used Per Year
COMFORT CONDITIONING			
Air Cleaner	50	4,320	216
Air Conditioner (room)	860	1,000	860
Blanket (Electric)	177	831	147
Dehumidifier	257	1,467	377
Fan (attic)	370	786	291
Fan (circulating)	88	489	43
Fan (roll away)	171	807	138
Fan (window)	200	850	170
Heater (portable)	1,322	133	177
Heating Pad	65	154	10
Humidifier	177	921	163
Lamps and Lighting	600	1,460	876
HEALTH AND BEAUTY			
Blow Dryer	1,000	121	121
Curling Iron	40	78	3
Hair Dryer	750	51	38
Heat Lamp (infared)	250	52	13
Hot Curlers	840	68	57
Shaver	.14	129	1.8
Sun Lamp	279	57	16
Tooth Brush	7	71	0.5
HOME ENTERTAINMENT			
Radio	71	1,211	86
Radio/Record Player	109	1,000	109
Projector (slide/ Movie)	350	5	1.8
Tape Recorder	5	624	3
TV Black and White	108	2,186	236
TV Color Solid State	250	2,200	550
TV Color Tube	300	2,200	660
TV Games	4	24	0.1
HOUSE WARES AND TOOLS			
Clock	2	8,760	17
Drill	5	1	0.1
Electric Typewriter	180	48	9
Flour Polisher	305	49	15
Sewing Machine	75	147	11
Table Saw	720	5	3.6
Vacuum Cleaner	630	73	46

Item	Average Wattage	Average Hours Per Year	Est. kwh used Per Year
FOOD PREPARATION			
Blender	386	39	15
Broiler	1,436	70	100
Can Opener	240	4	1
Carving Knife	92	87	8
Coffe Maker	894	119	106
Crock Pot	1,600	72	115
Deep Fryer	1,448	57	83
Dishwasher	1,201	302	363
Egg Cooker	516	27	14
Food Processor	600	52	31
Fry Pan	1,196	155	185
Hot Plate	1,257	72	90
Ice Cream Maker	10	6	1
Meat Slicer	600	12	7
Oven, Microwave	1,450	131	190
Pop Corn Popper	490	3	1
Range With Oven	12,200	96	1,171
Range With Self-Cleaning Oven	12,200	99	1,208
Roaster	1,333	154	205
Sandwich Grill	1,161	28	33
Toaster	1,146	34	39
Trash Compactor	400	125	50
Waffle Iron	1,116	20	22
Waste Disposer	445	67	30
FOOD PRESERVATION			
Freezer (15 cu. ft.)	341	3,504	1,195
Freezer Frostless, (15 cu. ft.)	440	4,0002	1,761
Refrigerator/Freezer (19 cu. ft.)	396	3,791	1,501
Refrigerator/Freezer Frostless, 14 cu. ft.	615	2,974	1,829
LAUNDRY			
Clothes Dryer	4,856	205	995
Iron (hand)	1,008	143	144
Washing Machine (automatic)	512	201	103
Water Heater	2,475	1,705	4,220
Water Heater (quick recovery)	4,474	1,705	7,810

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

POWER RATING AND COST ANALYSIS

After accumulating all the pertinent data from the preceding two sheets, list your 10 starred appliances under "Item" below. Then list the estimated kwh used per year - which you located on the electrical energy consumption chart. Complete computations to find cost per year, cost per day, and total costs. Complete the assignment by answering questions 12, 13, and 14.

Item	Estimated KWH used per year x	Current price per KWH =	Cost per year -	Days in a year =	Estimated cost per day
Example: Freezer, 15cu. ft.	1.195 KWH	.05	$59.75	365	$.16
1.		.05		365	
2.		.05		365	
3.		.05		365	
4.		.05		365	
5.		.05		365	
6.		.05		365	
7.		.05		365	
8.		.05		365	
9.		.05		365	
10.		.05		365	

11. TOTALS (sum of cost per year and cost per day column)

12. Which electrical appliance in your home has the highest wattage rating? ____________

13. Which appliance or device is operated for the greatest time? ____________

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

QUEST ACTIVITY

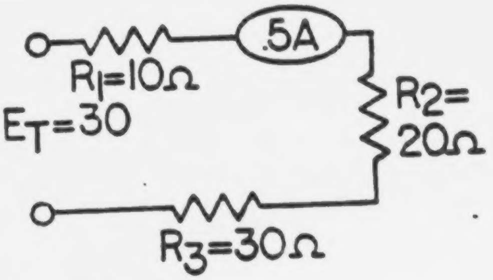
"UNIT 7"

MATCHING

1. Efficiency = ______
2. 746 Watts = 1______
3. Power = ______
4. Electrical energy unit
5. P equals E x I
6. Power Rating Unit
7. Power x time
8. Coulomb = ______

A. I^2R
B. Watt
C. Work
D. Output ÷ Input
E. 6.28×10^{18}
F. Horsepower
G. Watt's Law
H. Joule

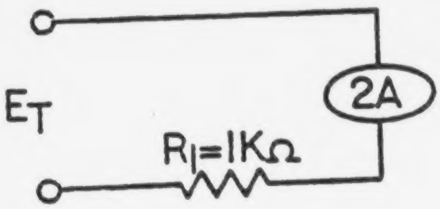
1. ☐
2. ☐
3. ☐
4. ☐
5. ☐
6. ☐
7. ☐
8. ☐


.5A
$R_1=10\Omega$
$E_T=30$
$R_2=20\Omega$
$R_3=30\Omega$

9. Find P_T

Show work

9. ☐


E_T
2A
$R_1=1K\Omega$

10. Find P_T

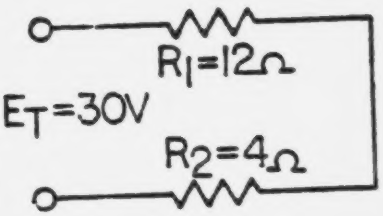
Show work

10. ☐

Name: ____________________

Date: ____________________

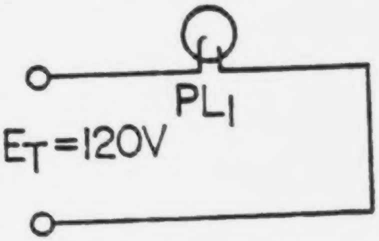
Period: ____________________


$R_1 = 12\Omega$
$E_T = 30V$
$R_2 = 4\Omega$

11. Find P_T

Show work

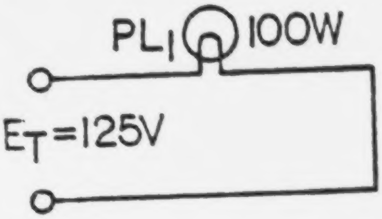
11. ☐



12. Resistance of PL_1 is 144 ohms. What is the wattage rating of the lamp? ________

Show work

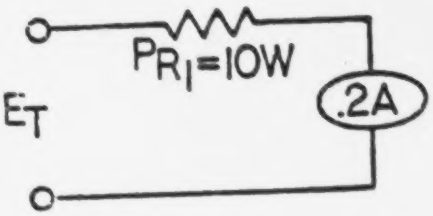
12. ☐


PL_1
100W
$E_T = 125V$

13. Find I_T

Show work

13. ☐


$P_{R_1} = 10W$
.2A
E_T

14. Find E_T

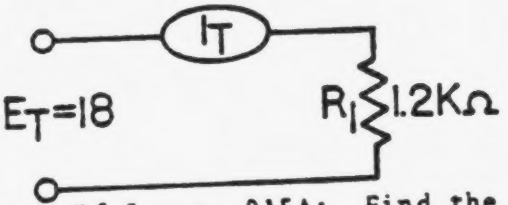
Show work

14. ☐

Name: ____________________

Date: ____________________

Period: ____________________



15. If I_T = .015A: Find the total power dissipated by the resistor.

15.

16. If a motor consumes 2238 watts of power:

A. What is the power rating in horsepower?

B. What is the power rating in kilowatts?

16A.

16B.

Show work

17. If a 10 ohm resistor is connected across an 18 volt source; how many watts of power are dissipated as heat?

17.

Show work

18. If a 300 watt lamp bulb is lit for 10 hours, how many kilowatt-hours of energy are used?

18.

Show work

Date: ______________

Period: ______________

19. ______________

19. If a 1000 ohm resistor is connected across an 18 volt source, it must have a wattage rating of at least:

1/4W, 1/2W, 1W, or 2W

Remember, if the wattage rating is too low, the resistor will burn up.

Show work

20. A toaster oven consumes 1350 watts of power. It is connected to a 120 volt source.

20A. ______________

20B. ______________

A. How much current flows through the heating element?

B. What is the resistance of the heater element?

Show work

Name: ____________________

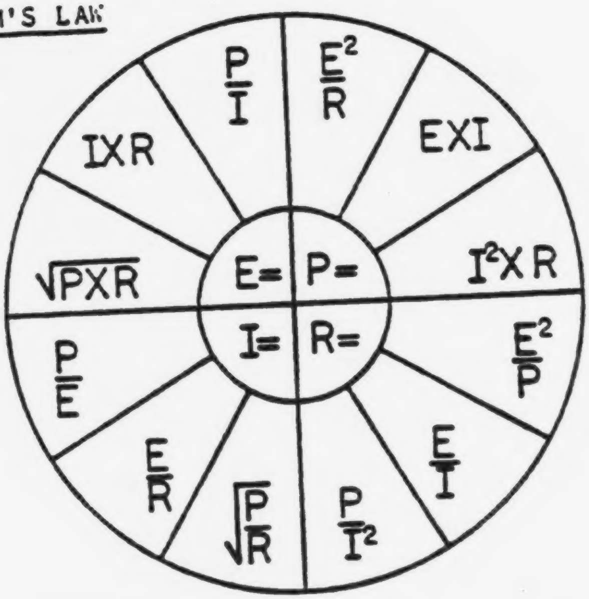
Date: ____________________

Period: ____________________

INFORMATIONAL HANDOUT

WATT'S LAW

WATT'S LAW and OHM'S LAW FORMULA WHEEL

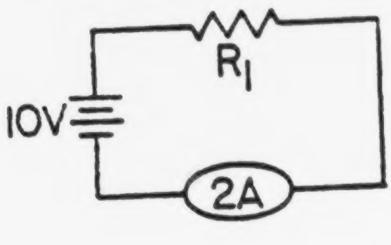

E=
P=
I=
R=
P/I
E²/R
EXI
I²XR
E²/P
E/I
P/I²
√P/R
E/R
P/E
√PXR
IXR

Terms - Symbols - and Units:

1. The term power (P) is measured in the unit watts (W).
2. The term voltage (E) is measured in the unit volts (V).
3. The term current (I) is measured in the unit amperes (A).
4. The term resistance (R) is measured in the unit ohms (Ω).

SAMPLE PROBLEMS:

Solving for power



E = 10V
I = 2A

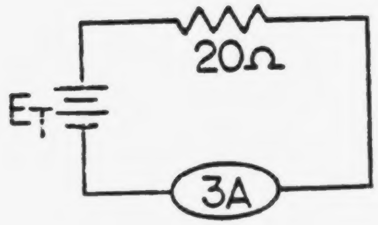
Formula: P = E x I
Enter values: P = 10 x 2
Multiply: P = 20
Enter unit: P = 20W

Name: ____________________

Date: ____________________

Period: ____________________

Solving for power



$I = 3A$
$R = 20$

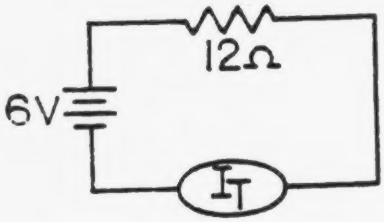
Formula: $P = I^2 \times H$

Enter values: $P = 3^2 \times 20$

Square "3": $P = 9 \times 20$

Enter unit: $\underline{P = 180\ W}$

Solving for power



Formula: $P = \frac{E^2}{R}$

Enter values: $P = \frac{6^2}{12}$

Square "6": $P = \frac{36}{12}$

Divide: $P = 3$

Enter unit: $\underline{P = 3W}$

Name: ____________________

Date: ____________________

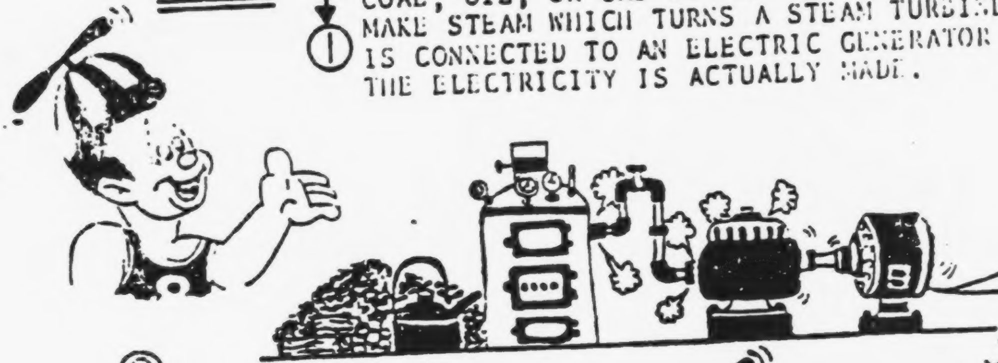
Period: ____________________

INFORMATIONAL HANDOUT

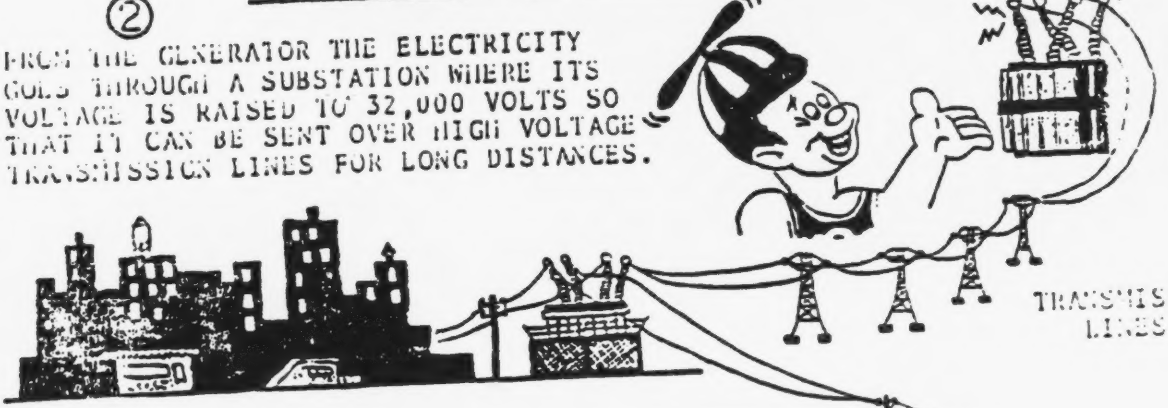
HOW ELECTRICITY IS GENERATED AND DISTRIBUTED

START

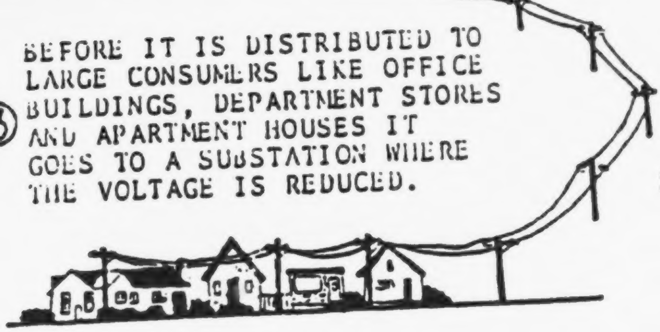
① COAL, OIL, OR GAS IS USED TO HEAT WATER TO MAKE STEAM WHICH TURNS A STEAM TURBINE. THIS IS CONNECTED TO AN ELECTRIC GENERATOR WHERE THE ELECTRICITY IS ACTUALLY MADE.



② FROM THE GENERATOR THE ELECTRICITY GOES THROUGH A SUBSTATION WHERE ITS VOLTAGE IS RAISED TO 32,000 VOLTS SO THAT IT CAN BE SENT OVER HIGH VOLTAGE TRANSMISSION LINES FOR LONG DISTANCES.



③ BEFORE IT IS DISTRIBUTED TO LARGE CONSUMERS LIKE OFFICE BUILDINGS, DEPARTMENT STORES AND APARTMENT HOUSES IT GOES TO A SUBSTATION WHERE THE VOLTAGE IS REDUCED.



④ BEFORE THE ELECTRICITY IS DELIVERED TO PRIVATE HOMES, SMALL STORES, AND SCHOOLS, THE VOLTAGE IS FURTHER REDUCED.

FINISH

120/240 V

Name: ______________

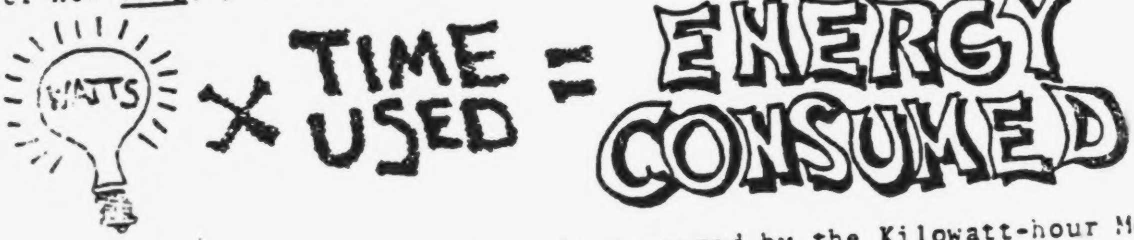
Date: ______________

Period: ______________

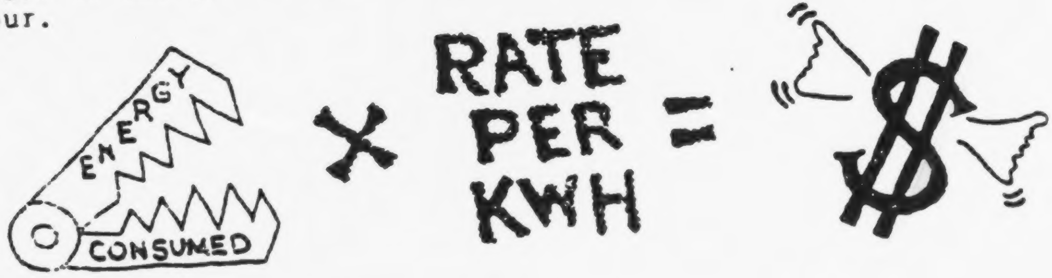
INFORMATIONAL HANDOUT

MEASURING AND MONITORING ENERGY CONSUMPTION

Wattage ratings printed on light bulbs and appliances indicate the rate at which the device uses electric energy. If you know the speed of a car, and the time operated, you can find the distance traveled. In the same way if you know the rate at which electrical energy is used, and for how long, you can find the total energy consumed.



The energy consumed in your home is measured by the Kilowatt-hour Meter, which is monitored by the local power company. The power company in turn computes your monthly electric bill based upon the number of kilowatt-hours of energy consumed and the rate schedule which prices each kilowatt-hour.



READING THE KILOWATT-HOUR METER

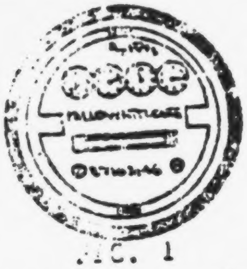


FIG. 1

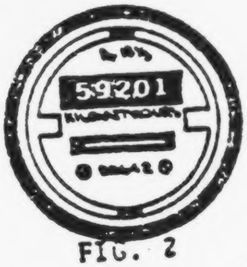


FIG. 2

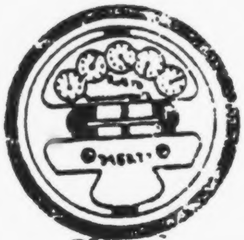


FIG. 3

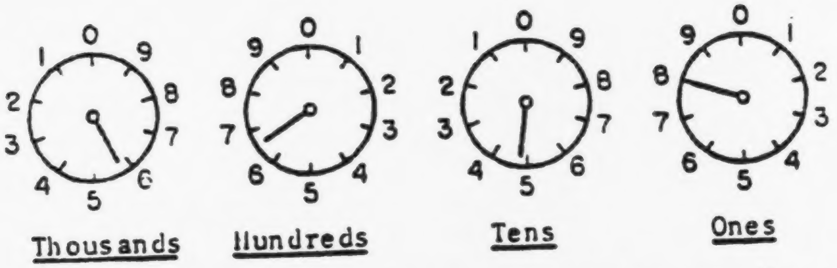
The drawing above shows several styles of kilowatt-hour meters. Locate your meter at home - however, it may be different from those pictured.

Reading the meter in fig. 2 is a simple matter, but reading the pointer style meter is slightly more complex.

Name: ______________

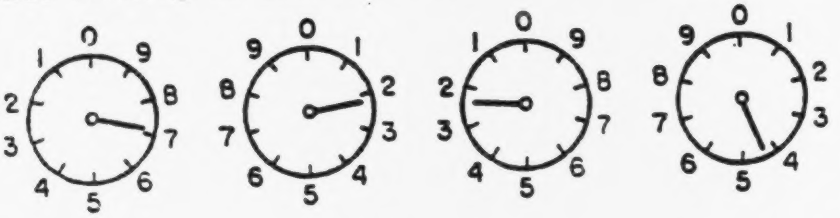
Date: ______________

Period: ______________

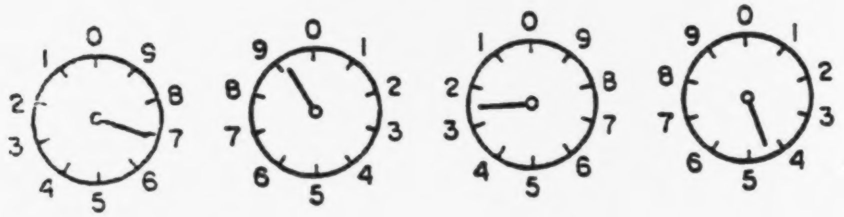


The meter pictured above is indicating a reading of 5648 kwh's. Notice; even though the pointer falls between two numbers, you always read to the lower value; also, each dial corresponds to a place value in our numbering system (ones, tens, hundreds, etc.)

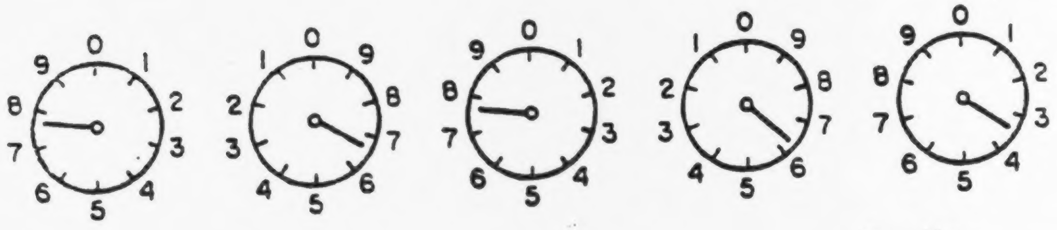
What reading is indicated on the kwh meters below?



Reading______________



Reading______________



Reading______________

ANSWERS: (1) 7224 (2) 6924 (3) 76763

Name: ____________

Date: ____________

Period: ____________

COMPUTING ELECTRIC ENERGY COSTS

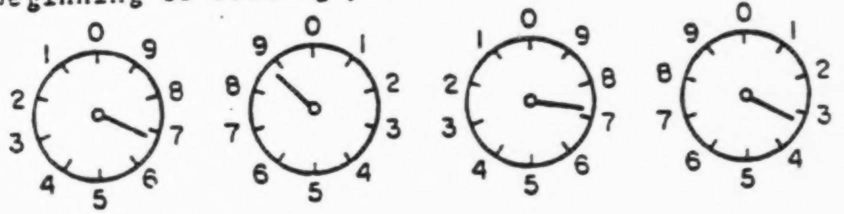
Being able to read the kwh meter is only part of the process in determining monthly energy costs. We will now examine how a power company computes your monthly electric bill.

Step 1. Determine the number of kwh's used per billing period by subtracting beginning meter reading from ending meter reading.

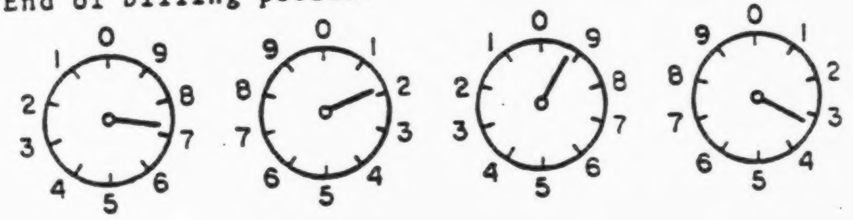
Step 2. Using the rate schedule below calculate the cost by grouping, and multiplying the number of kwh by the cost per kwh. Total the charges to find total cost.

EXAMPLE:

Beginning of billing period:



End of billing period:



Rate Schedule

Fixed customer charge--------------------------------$1.60
Energy charge (includes energy cost adjustment)
First 300 kwh, per kwh---------------------------$ .045
Over 300 kwh, per kwh ---------------------------$ .046

Step 1. Determine the number of kwh's used.

End of period reading	7193
Beginning of period reading	- 6873
Difference	320 kwh's

Step 2. Calculate cost using rate schedule.
Fixed customer charge------------------------------------$ 1.60
First 300 kwh, at $.045 each (300 x .045)-------$13.50
Over 300 kwh, at $.046 each (20 x .046)---------$ .92
Total----------$16.02

Name: ______________________

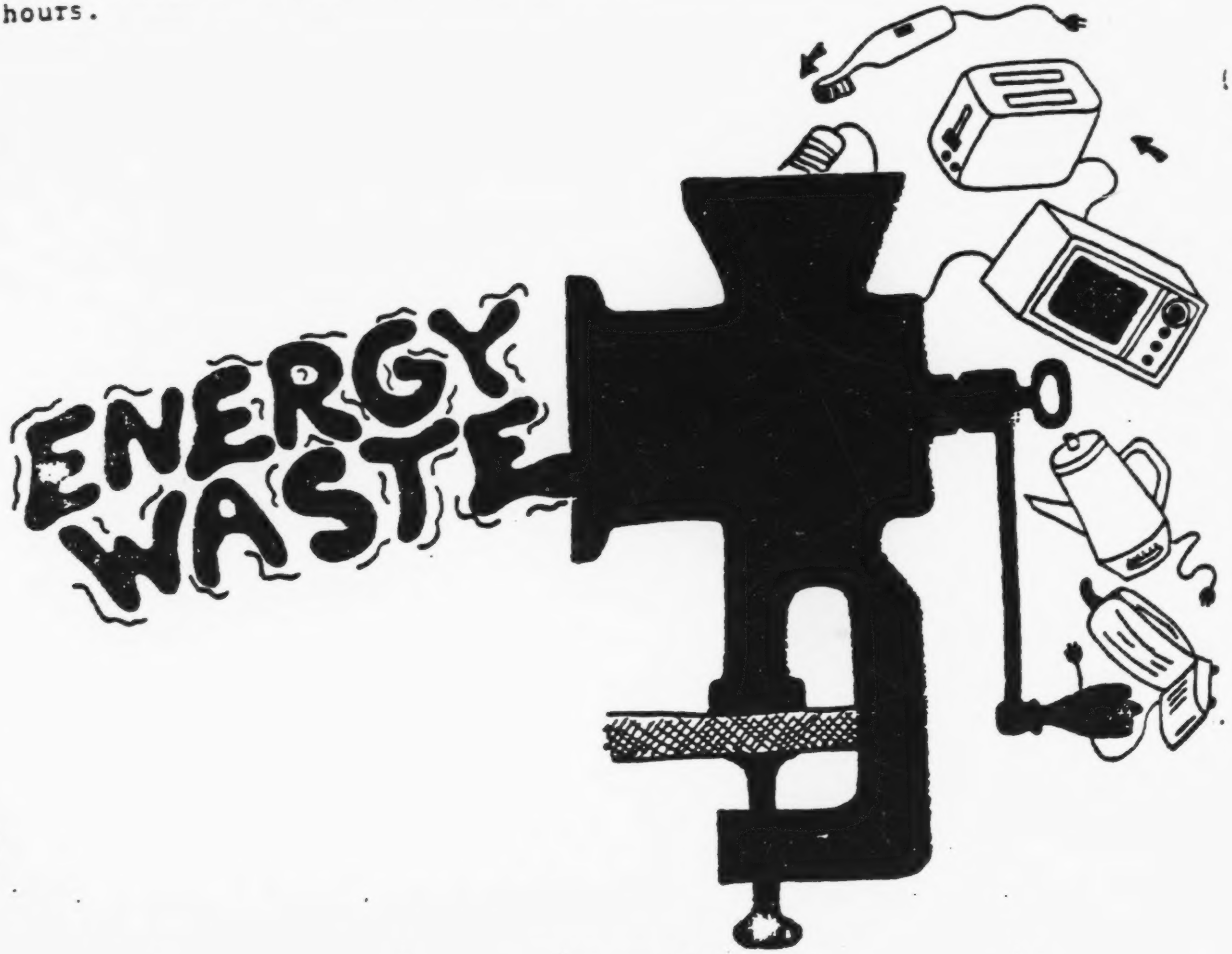
Date: ______________________

Period: ______________________

How many times have you been told to turn off the lights when you leave a room, or to be sure to turn off the TV or radio when you are not watching or listening? Why all this concern over using a "little" electric energy? Well, obviously it costs money to operate these devices, but more important it wastes energy! Let's try to compute the cost of operating two 100 W lamps for 6 hours - A typical night of study.

		EXAMPLE
Step 1.	Find total power in watts.	Two 100 W lamps = 200 W
Step 2.	Convert watts to kilowatts.	200 W = .2kw
Step 3.	Determine the time - in hours - that the device is in operation.	Given as 6 hours.
Step 4.	Multiply kilowatts x time in hours to find kilowatt-hours.	.2 kw x 6 hr = 1.2 kwh
Step 5.	Multiply kwh by the cost per kwh. To find cost of operation.	1.2 kwh x $.05 = $.06

Thus it will cost approximately 6¢ to operate the two 100 W lamps for 6 hours.



LIII-U7-9.

电能与电功率 (ELECTRICAL ENERGY & POWER,
技術語彙

circuit breaker = 断路器,断路闸阀

exceeds = 超过.

set value = 預先訂定的值.

reset = 再設定.

trips = 跳闸,跳闸,以轻快的步伐走.

coulomb = 庫侖(电量單位)

magnitude = 量,數量,大小,尺寸.

decibel (dB) = 分貝

logarithmic = 对数的.

efficiency = 效率

effective = 有效的.

impossible = 不可能的.

formula = 公式.

work = 功.

energy comsumption = 能量消耗

kilo-watt-hour = 千瓦小時.

melts = 熔融,熔掉.

heat sink = 热辐发器,热交换器.

device = 設備,装配.

carry ---- away×× = 帶走---從××.
(從××把----帶走)

horsepower = 馬力、

mechanical = 机械性的.

conversion = 轉換,換位法.

loss = 損失,損耗

joule = 焦耳

monitored = 監督,被監視.

dissipation = 消散,耗散,損耗.

LIII-47-15

volt drop = 电压下降.

wattage rating = 瓦特數.

capacity = 能力

household appliances = 家庭用电器

entertainment = 娛樂 餘興.

in turn = 轉換為

perform = 履行,完成,

wasted = 被浪費

conservation = 保存,存續

efforts = 有效力. 效力

air cleaner = 空氣淨潔器

air conditioner = 冷氣机.

blender = 攪拌器

blow dryer = 吹風机

broiler = 烤肉机.

carving knife = 电動切肉机

clothes dryer = 乾衣机

coffee maker = 煮咖啡器

crock pot = 电热壶

curling irons = 电燙髮夾.

dehumidifier = 除濕器.

deep fryer = 油炸鍋

drill = 电鑽

egg cooker = 煮蛋器

blanket = 毛毯

can opener = 開罐器

typewriter = 打字机

TV games = (利用电視銀幕的)遊

fan = 电風扇

floor polisher = 打(地板)臘机

hot curlers = 电热壶.

humidifier = 濕润器

LIII-U7-15, -16,

iron = 电熨斗.
pop corn popper = 爆玉米花机
oven = 烤箱
microwave = 微波爐.
projector = 放映机
record player = 錄音机
radio = 收音机
range = 电爐灶.
refrigerator = 电冰箱
freezer = 冷凍箱
roaster = 烤麵包机
grill = 烤.炙
sewing machine = 縫衣机
shaver = 电鬍刀
sun lamp = 日光燈, 太陽燈
table saw = 桌鋸. 台鋸

trash compactor = 垃圾碎屑机
vacuum cleaner = 吸塵清洗机
waffle iron = 做軟餅的电熱鉄模
washing machine = 洗衣机
waste disposer = 廢物處理机
water heater = 电熱水器
chart = 表格, 图表
indicates = 指示出.
average = 平均的.
estimated = 估計的
preparation = 預備.
preservation = 儲存.
laundry = 洗衣房,
analysis = 分析
accumulating = 積存
pertinent = 有关於的, 適切的.

LIII-U7-16, -23. -24.

complete = 完全

computation: 計算

assignment = 任務, 研究課題

square = 平方 (自乘兩次).

generated = 產生.

distributed = 分配

coal = 煤

oil = 燃燒油

gas = 天然氣

steam = 蒸氣.

turns = 轉动

steam turbine = 蒸氣渦輪.

electric generator = 发电机

actually = 真正地

substation: 变电所

raised = 被升高

transmission line = 輸电线

consumers = 使用者, 消耗者

reduced = 被降低

delivered = 輸送

private = 私人的

further = 更, 再

travel = 行程.

local power company = 本地电力公司

electric bill = 电费單據.

rate schedule = 算計步驟.

styles = 型式. 類别

complex = 複雜

pointer: 指示針

falls = 停在. 指在.

dial: 錶面盤

cost = 費用. 价錢

LIII-U7-27,-28

billing period = 單據計費的期间.

subtracting = 減.

multiplying = 乘

fixed : 基本的, 固定的.

charge = 收費, 費用

adjustment = 調整

difference = 差額.

turn off = 関掉(切断)

wastes energy = 浪費电能

ELECTRONICS CURRICULUM
VOCATIONAL TRAINI[illegible]SSON PLAN # VIII

INDUCTANCE

Teaching Materials Source ____________________

Chapter ____________, pages ____________

Lab Manual pages ____________

Additional Instructor Materials ____________________

Main concepts student will learn:

1. write the names and abbreviations of hte various units of measurements for inductance, and draw the schematic symbols for both fixed and variable inductors.
2. define the terms inductance, self inductance, and mutual inductance.
3. solve for total inductance of inductors either in series or parallel utilizing the proper formula and units of measurement.
4. explain and compute problems involving RL time constants and inductive reactance while employing the values given and solving for the unknown.
5. state the function, construction, and characteristics of transformers, and draw the proper schematic symbol for this component.
6. when given the number of turns in the kprimary and secondary coils, and either, the voltage or current in the primary and secondary coil, solve for the remaining unknown.

Technical Vocabulary

see Glossary

Related General Vocabulary

see Glossary

Teaching Activity

see attached

Length of Lesson

3 weeks

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Materials and Notes

1. Illustrate the use of transformers as related to consumer products which are familiar to students, then disunite internally a large transformer while identifying parts and purpose. These kinds of activities will help promote a comprehensiion of the relative importance of transformers and remove some of the mystic associated with this common electrical device.

2. When defining the term "inductance" with the property of inertia and then use the analogous situation of pushing a car uphil and then trying to stop it on its downhill flight. Inertia is the property of an object to oppose any change in its direction of motion while inductance opposes any change in current flow.

TEACHING ACTIVITY

1. The secret to the understanding of ideas related to inductance lies with the mastery of basic magnetism principles, explain or review those that are essential to the subject matter of this unit.

   Remember to point out during a presentation that the formulas for adding inductors in series or in parallel are exactly the same as those for totaling resistors in series or in parallel. Explain that coils may interact depending on physical placement and that this characteristic can necessitate slight formula modification.

   Once the fundamental concepts have been absorbed by the class, it is appropriate to concentrate on reactance. Impress on the students the similarity between "X_c" and "X_L", and even the concept of impedance may be introduced informally as a quantity which allows the solving for total opposition of any combination of R, X_c, and X_L.

   A description on transformer operation is generally easily digested by students, however, many students incorrectly believe that transformers produce power. it is advantageous then to stress that power in equals power out and that there really is no gain in total power within a transformer.

   In addition to formal laboratory experiments, certain laboratory exploration can assist the instructor in vividly illustrating procedures for testing inductors and transformers. have students list the most common defects that they feel might occur with these components , then elaborate on various testing techniques such as; continuity, voltage checks, component performance observation, etc.

SCORE:
GRADE:

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WORKSHEET

VOCABULARY - KNOW YOUR DEFINITIONS

Below you will find short definitions for a number of electrical terms. Your job is to find the term that best fits the definition. If your're imaginative you might refer to your technical glossary.

DEFINITION	TERM
EXAMPLE:	
A. The basic unit for measuring voltage.	A. volt
YOUR TURN:	
1. Two metal plates separated by a dielectric.	1.
2. A measure of an insulators ability to withstand high voltages.	2.
3. Employs an oxide layer as a dielectric.	3.
4. Basic unit of measurement for capacitance.	4.
5. The AC resistance of an inductor or capacitor.	5.
6. The normal DC operating voltage of a capacitor.	6.
7. The metal surfaces of a capacitor upon which charges are stored.	7.
8. A device whose capacitance can be changed by mechanical means.	8.
9. The ability of a device to store a charge and oppose a change in voltage.	9.
10. The voltage at which dielectric damage begins.	10.
11. The general category of capacitors which must be connected into a circuit according to polarity.	11.
12. Must be connected into the circuit observing positive and negative potentials.	12.
13. Time required to charge a capacitor to 63.2% of its full charge.	13.

Name: ____________________

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14. A rating of the change in capacitance due to temperature.

15. A characteristic of a capacitor which allows it to be connected into a circuit in either direction.

16. "AC resistance" of a capacitor.

17. Electrical force which exists between two charged bodies.

18. Insulating material between the two plates of a capacitor.

19. Combining of positive and negative charges to produce a net charge of zero.

20. A more common unit of capacitance equivalent to .000001 farads.

14. ☐

15. ☐

16. ☐

17. ☐

18. ☐

19. ☐

20. ☐

SCORE:

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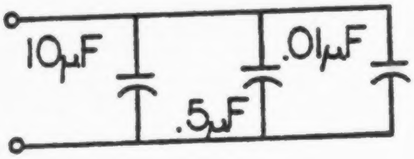
WORKSHEET

CAPACITORS AND CAPACITANCE

1. ☐

1. Find the total capacitance in the following circuit.



Show work

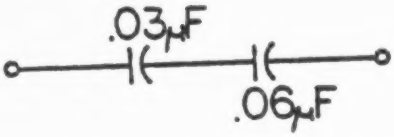
2. ☐

2. Find the total capacitance when .01μF, .02μF, .05μF, and a .1μF capacitor are connected in parallel.

Show work

3. ☐

3. Solve for C_T in the following circuit.



Show work

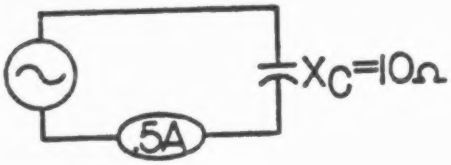
4. ☐

4. Find the total capacitance when a 24μF, 8μF, and a 12μF capacitor are connected in series.

Show work

5. ☐

5. Find E in the following circuit.



Show work

Name: ____________________

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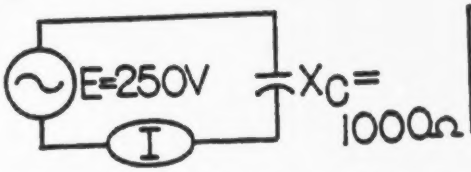
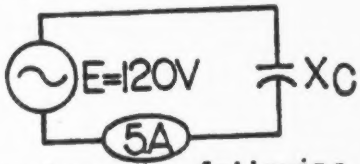
6. Find the current in the following circuit.



Show work

6.

7. Find the capacitive reactance in the following circuit.



Show work

7.

8. Complete the following chart:

A. After 1T, the capacitor is charged to _____% of full charge.

8A.

B. After 2T, the capacitor is charged to _____% of full charge.

8B.

C. After 3T, the capacitor is charged to _____% of full charge.

8C.

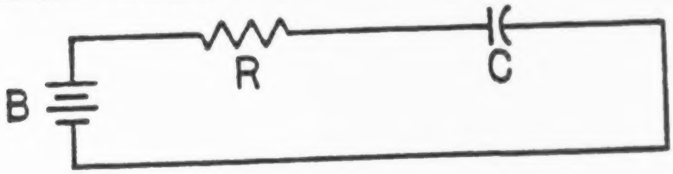
D. After 4T, the capacitor is charged to _____% of full charge.

8D.

E. After 5T, the capacitor is charged to _____% of full charge.

8E.

9. Find the capacitive time constants in the following problems: (Remember R in ohms, C in micro farads, then T is in μsec).



A. Find T if R = 1M ohm and C = .05μF. ____________

9A.

B. Find T if R = 270 ohms, C = 47μF. ____________

9B.

C. Find T if R = 91k ohms, C = .2μF. ____________

9C.

Name: ____________________

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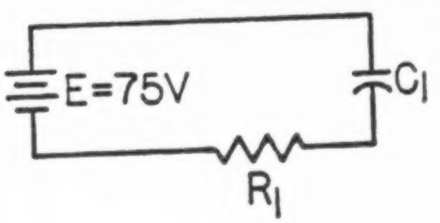
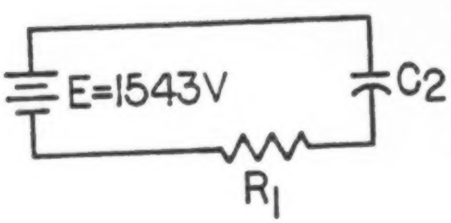
10. Find the state of charge (the charge across the capacitor) for the following capacitors circuits.

A. Find the state of charge across C_1 after 3T. ____________ 10A. ☐



Show work

B. Find the state of charge across C_2 after 5T. ____________ 10B. ☐

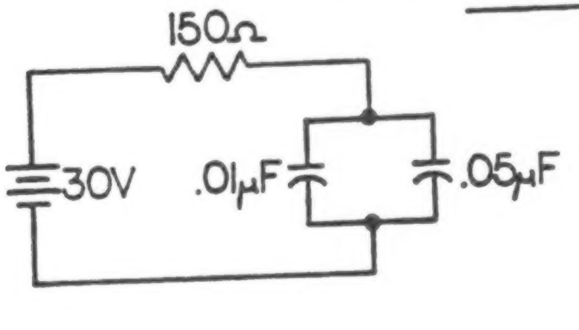


Show work

11. A. Find T; ____________ 11A. ☐

B. How long will it take in micro seconds, for C to be fully charged? ____________ 11B. ☐

C. What is the state of charge of C after 4T? ____________ 11C. ☐



Show work

SCORE:

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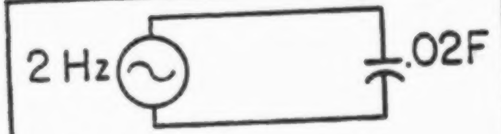
WORKSHEET

CAPACITIVE REACTANCE

Solve the following problems for the capacitive reactance (X_C) of the circuit. Remember to change frequency and capacitance to their basic unit.

Round all answers to include two decimal places only. Example: 65.78521 = 65.79.

1.

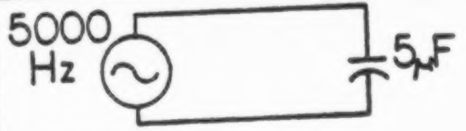


Find X_C

Show work

1. ____________

2.

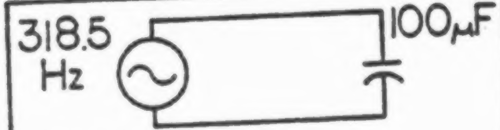


Compute X_C

Show work

2. ____________

3.

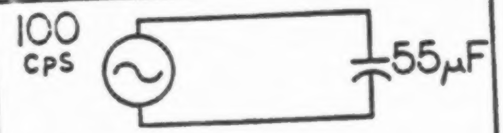


Calculate X_C

Show work

3. ____________

4.



Find X_C

Show work

4. ____________

5. A coupling capacitor in a radio transmitter has a capacitance of .0025μF. What is the reactance at a frequency of 980kHz.

Show work

5. ____________

SCORE:

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Period: ________________

WORKSHEET

QUEST ACTIVITY

"UNIT 11"

1.	The basic purpose of all capacitors is to store a __________ and release that charge back into the circuit at the appropriate time.	1. ☐
2.	Air is used as a dielectric in capacitors. True or False?	2. ☐
3.	Electrons pass through the dielectric of a capacitor during the charging process. True or False?	3. ☐
4.	It can be said that a capacitor (4A)______ AC but (4B)______ DC.	4A. ☐ 4B. ☐
5.	Since electrons do not pass through the dielectric of a capacitor, it is impossible to have a flow of electrons in a circuit containing a capacitor. True or False?	5. ☐
6.	The basic unit of capacitance is the farad. Usually, it is more convenient to use a smaller unit equal to one-millionths of a farad, called a __________.	6. ☐
7.	An even smaller unit of capacitance equal to one-trillionths of a farad, called a ________.	7. ☐
8.	Convert .00005μF to pF.	8. ☐
9.	Convert 1800pF to μF.	9. ☐
10.	Increasing the plate area of a capacitor increases its capacitance. True or False.	10. ☐
11.	Increasing the space between the plates of a capacitor increases its capacitance. True or False?	11. ☐
12.	The maximum voltage that can be steadily applied to a capacitor is called __________. (Breakdown voltage, or working voltage.)	12. ☐
13.	A capacitor can hold a charge only for a short time. True or False?	13. ☐

Name: ____________________

Date: ____________________

Period: ____________________

14. Write the formula for finding total capacitance in a series circuit.

14. ☐

15. Write the equation for finding total capacitance in a parallel circuit containing 3 or more unequal value capacitors.

15. ☐

16. When capacitors are connected in series, the total capacitance increases. True or False?

16. ☐

17. What type of dielectric does a tubular paper capacitor use?

17. ☐

18. Capacitor manufacturers usually stack or roll the plates and dielectric in order to reduce ________.

18. ☐

19. Mica and ceramic capacitors generally share the property of high stability, but relatively low farad value. True or False?

19. ☐

20. The dielectric in an electrolytic capacitor consists of an oxide layer formed on the positive plate. True or False?

20. ☐

21. List three characteristics of electrolytic capacitors that differ from other capacitors.

21A. ☐

21B. ☐

21C. ☐

22. In what two ways may the capacitance of a variable capacitor be changed?

22A. ☐

22B. ☐

23. In terms of time constants, how much time is required for a capacitor to charge to 94.9% of full charge?

23. ☐

24. It requires 6T for a capacitor to just reach a fully charged state. True or False?

24. ☐

25. If $R = 15k\Omega$ and $C = .1\mu F$ then the time constant must equal ______________ sec.

25. ☐

Show work

Name: ______________

Date: ______________

Period: ______________

26. If the source voltage in an RC circuit is 50V, what is the "state of charge" of the capacitor after 2T?

Show work

26. ☐

27. Give the formula for computing the reactance offered by a capacitor in an AC circuit.

27. ☐

28. What two factors effect the AC resistance of a capacitor?

28A. ☐

28B. ☐

29. Find X_C given that the circuit frequency is 10kHz, and the total capacitance is 20 micro farads.

Show work

29. ☐

30. Explain the phase relationship between voltage and current in a purely capacitive circuit.

30. ☐

Test Number ________

LII-U12

UNIT EXAM

INDUCTANCE

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question there is only one correct answer for each question.

1. A voltage is induced in a wire anytime it cuts through a magnetic field, or the magnetic field moves through the wire. (T-F)

2. A transformer consists of two or more coils wound around a common core. (T-F)

3. The inductance of a coil is effected by the amount of current flowing through it. (T-F)

4. Total inductance increases when inductors are connected in parallel. (T-F)

5. An inductor opposes a change in current flow. (T-F)

6. A CEMF and a self-induced voltage are one and the same. (T-F)

7. The counter-electromotive force produced in an inductor opposes the applied current. (T-F)

8. If the motion of the magnetic field were reversed, the CEMF produced in the inductor would also reverse polarity. (T-F)

9. A transformer will not produce an output in a circuit utilizing pure DC current. (T-F)

10. Mutual inductance is the magnetic effect which explains the operation of a conductor. (T-F)

11. The inductive time constant is a measure of how rapidly an inductor allows current to rise to its steady value. (T-F)

12. The opposition to AC current provided by a transformer is called inductive reactance. (T-F)

13. If the primary winding of a transformer contains more turns of wire than the secondary winding, the transformer will act as a step-up transformer. (T-F)

14. Inductive reactance increases as frequency increases. (T-F)

15. The input and output voltages of a transformer are in-phase. (T-F)

16. Power transformers may contain more than one secondary winding. (T-F)

17. Iron-core inductors are often called chokes. (T-F)

18. The winding of a transformer which provides the output is called the second winding. (T-F)

19. The letter symbol for an inductor is I. (T-F)

20. The maximum power that the secondary winding of a step-up transformer can deliver to its load is always slightly less than, or equal to the power in the primary winding. (T-F)

21. Inductance is the property of an electric circuit that opposes a change in:
(A) current, (B) applied voltage, (C) induced voltage, (D) magneti
field.

22. The basic unit for inductance is the:
(A) ohm, (B) reactance, (C) farad, (D) henry.

23. The thin sheets of metal used to make up the core of an iron-core inductor or transformer are called:
(A) pieces, (B) laminations, (C) strips, (D) sheets.

24. The basic unit of inductive reactance is the:
(A) hertz, (B) ohm, (C) volt, (D) watt.

25. When the current through an inductor starts to change, the applied current is prevented from instantly reaching its final value by the:
(A) counter emf, (B) resistance of the coil, (C) eddy currents,
(D) applied emf of the circuit.

26. Energy is stored in the magnetic field around an inductor. When the current flow decreases, the collapsing magnetic field:
(A) returns energy to the circuit, (B) takes energy from the circuit,
(C) increases the flux, (D) does not induce a voltage.

27. In a transformer, energy is transfered from the primary to the secondary winding by means of a:
(A) core, (B) magnet, (C) winding, (D) magnetic field.

28. A transformer that has more turns in the secondary than in the primary
(A) steps-up voltage, (B) steps-up current, (C) steps-down voltage,
(D) steps-up power.

29. Transformers are rated in which of the following ways?
(A) Turns ratio, (B) input voltage verse output voltage, (C) input impedance verse output impedance, (D) all of the above.

30. A transformer consisting of one continuous winding with several taps for taking off different voltages is called:
(A) an isolation transformer, (B) a power transformer, (C) a current transformer, (D) an autotransformer.

31. Since a transformer operates because of a magnetic linkage between its windings, the device is said to possess the property of mutual:
(A) operation, (B) inductance, (C) magnetism, (D) links.

32. A transformer that has a turns ratio of 1:1 is used for:
(A) impedance matching, (B) changing frequency, (C) isolation, (D) stepping-up voltage.

33. The transformer turns ratio is the ratio of:
(A) secondary voltage to secondary current, (B) primary windings to secondary voltage, (C) secondary windings to primary windings, (D) primary current to secondary current.

34. Iron core transformers have the operating characteristic that the power in the secondary is equal to:
(A) E_p x I_s, (B) E_s x I_s, (C) E_p x I_p, (D) both B and C.

35. When two coils, one 5 henrys and the other 3 henrys, are connected in series and are so far apart that they cannot influence each other, the total inductance will be:
(A) 2 henrys, (B) 15/8 henrys, (C) 8 henrys (D) 8/15 henrys.

36. The opposition of an inductor to current flow (X_L):
(A) depends on the magnitude of the applied voltage, (B) varies directly with frequency, (C) varies inversely with frequency, (D) depends only on the resistance of the coil.

37. The inductive reactance of a 4-henry coil at 100Hz is:
(A) 400 ohms, (B) 628 ohms, (C) 2,512 ohms, (D) 5,024.

38. When two inductors are connected in parallel: one a 30mh choke and th other a 60mh choke, the total inductance will be:
(A) 90 mh, (B) 30mh, (C) 180mh, (D) 20mh.

39. A transformer used on a 120-volt line has a primary with 60 turns and provides 720 volts output. The secondary winding should have:
(A) 240 turns, (B) 10 turns, (C) 360 turns, (D) 720 turns.

40. If a 1:4 step-up ideal transformer has a primary voltage of 100 volts, the secondary voltage is:
(A) 25 volts, (B) 400 volts, (C) 60 volts, (D) 141 volts.

Name: ____________________

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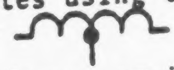
Period: ____________________

INDUCTANCE

TECHNICAL GLOSSARY

AUTOTRANSFORMER:	A type of transformer utilizing only one tapped coil of wire. It operates using the principle of self inductance. Symbol:  Letter symbol: T
CENTER-TAPPED:	A type of transformer or inductor which has an additional lead connected to the center of the secondary coil. A center-tapped transformer provides the option of a second output voltage between the center-tapped lead and one of the secondary leads.
CHOKE:	Another expression for indicating an inductor. A choke is used to oppose or "choke off" the flow of alternating current.
CORE:	The magnetic path within an inductor or transformer. Usually a core forms the center of a coil or transformer, supporting wire turns and concentrating magnetic flux lines. Two basic core designations are air core or iron core.
COUNTER ELECTROMOTIVE FORCE:	A voltage produced in a wire by self-induction. This induced voltage opposes, or has the opposite polarity, of the applied circuit voltage. This phenomenon is common in inductors and transformers, sometimes called "back EMF". Abbrev. CEMF
EDDY CURRENTS:	Circular currents induced in the core of generators or transformers caused by a varying magnetic field. These currents do not serve a useful purpose, but rather represent a loss.
FLUX LINES:	Lines of force produced by a magnetic field.
HENRY:	The basic unit of inductance. The henry is a relatively large unit, thus the more common inductance units are the millihenry and microhenry. Letter symbol: H
HYSTERESIS:	A "loss" in an iron-core device due to remaining (residual) magnetism in the iron-core after each cycle. This residual force must be removed before the core material can be remagnetized in the reverse direction.
INDUCTANCE:	The property of an electric circuit which opposses a change in current flow. This opposition to current change is produced by an expanding or collapsing magnetic field within a coil or wire. Inductance is measured in the basic unit henrys.

Name: ____________________

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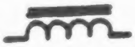
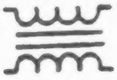
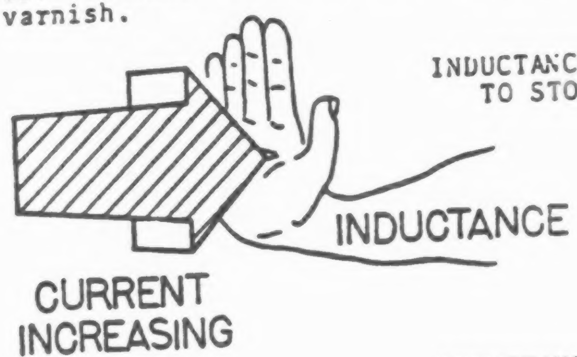
INDUCTIVE REACTANCE:	The AC resistance offered by an inductor. Inductive reactance is computed by the following formula: $X_L = 2\pi fL$. Abbreviation X_L and its basic unit of measurement is the ohm.
INDUCTOR:	A coil of wire wrapped around an air or iron core. Symbol:  Letter symbol: L
LAMINATIONS:	Thin layers or sheets of iron stacked together to form the core for iron-core transformers or inductors. Cores are made with laminations to reduce eddy currents.
LENZ'S LAW:	A law which states that the induced EMF in any circuit is always in such a direction as to oppose the force which "generated" that EMF.
MUTUAL INDUCTION:	The transfer of energy from one coil to an adjacent coil by means of a varying magnetic field. Transformers operate on this principle; so that, as the magnetic field in the primary winding expands and collapses, a voltage is induced in the secondary winding.
PERMEABILITY:	A measure of the ease with which a material will conduct magnetic line of force.
PRIMARY WINDING:	The winding of a transformer which receives the input energy. Abbrev. P
RL TIME CONSTANT:	The time required for an inductor to allow 63.2% of maximum current to flow when a DC voltage is applied. Formula: $T = \frac{L}{R}$
SATURATION:	In the iron core of an inductor or transformer, saturation describes the condition when the maximum number of flux lines possible are established in the core.
SECONDARY WINDING:	That winding of a transformer whose energy is produced by electromagnetic induction from the primary winding. The secondary winding provides the output of the transformer, and many transformers are designed with more than one secondary winding.
SELF INDUCTANCE:	The process by which a varying current (causing a varying magnetic field), induces a voltage in the adjacent conductor or coil of an inductor.
SLUG:	A powdered iron core, in an inductor, which can be moved to vary inductance.
STEP-DOWN:	A type of transformer that has fewer windings in the secondary than in the primary, hence a decrease in voltage from primary to secondary.

Name: ____________________

Date: ____________________

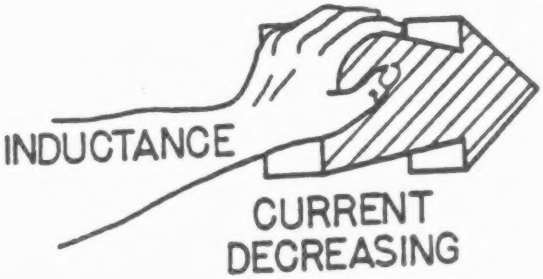
Period: ____________________

STEP-UP:	A type of transformer that has more windings in the secondary than in the primary, thus allowing an increase in voltage from primary to secondary.
TRANSFORMER:	A device consisting of two or more coils wound around a common core. Energy is transferred from one coil (primary winding) to another coil (secondary winding) by means of mutual induction. A transformer is used to step up or step-down AC voltage or current. Symbol:  Letter symbol: T
TURNS RATIO:	The ratio of the number of turns in the secondary of a transformer to the number of turns in the primary.
WINDING:	A turn (one revolution) of insulated wire, wrapped aroun an air or iron core. The insulating material on inductor or transformer windings is generally enamel or varnish.



INDUCTANCE TRIES TO STOP IT

INDUCTANCE TRIES TO KEEP IT GOING



SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

INDUCTANCE AND INDUCTORS

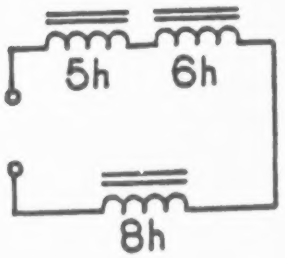
1. Inductance is the property of an electric circuit, or device, which opposes a change in circuit ________.	1.
2. An inductor utilizes an expanding and collapsing ________ ________ to provide inductance.	2.
3. The basic unit of measurement for inductance is the ________.	3.
4. Other common sub-units of inductance are the (A) ________ and (B) ________.	4A. 4B.
5. Basically, an inductor consists of a coil of insulated wire wrapped around an air or iron ________.	5.
6. If the number of turns of wire are increased, the inductance of the inductor will ________.	6.
7. The letter symbol for an inductor is ________.	7.
8. Draw the schematic symbol for an air core inductor.	8.
9. As ________ is passed through a conductor, a magnetic field appears about the conductor forming a circular field.	9.
10. As the magnetic field expands around a conductor, a voltage is developed in that conductor by a process called ________-________.	10.
11. As the current flow through an inductor increases a voltage is developed within the coil which opposes the applied voltage. This induced voltage is called the ________.	11.
12. A CEMF is produced in an inductor only when the applied voltage is increasing or decreasing. (True - False)	12.

Name: ______________________

Date: ______________________

Period: ______________________

13. In order for an inductor to operate functionally in a DC circuit, the DC voltage must __________ or pulsate.	13.
14. The formula $L_T = \frac{L_1 \times L_2}{L_1 + L_2}$ is used to find the total inductance of two inductors connected in __________.	14.
15. To obtain the greatest total inductance, two inductors should be connected in __________.	15.
16. The R-L time constant indicates the time required for the inductor to allow 63.2% of maximum __________ to flow in the circuit.	16.
17. When the applied AC voltage across an inductor is maximum, the current flow will be __________.	17.
18. In a purely inductive circuit, the (A) __________ leads the (B) __________ by 90°.	18A. 18B.
19. The opposition to current flow developed by an inductor in an AC circuit is called __________ __________.	19.
20. Inductors offer the greatest opposition to current flow in an __________ (AC or DC) circuit.	20.
21. The letter symbol for inductive reactance is __________	21.
22. Inductive reactance is measured in the basic unit __________.	22.
23. What is the formula for finding the AC resistance of an inductor?	23.
24. What is the total inductance of the following circuit?	24.



Show work

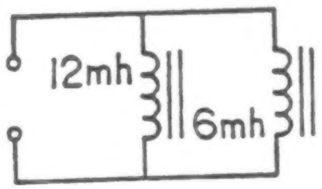
Name: ____________

Date: ____________

Period: ____________

25. What is the total inductance in the following parallel circuit?

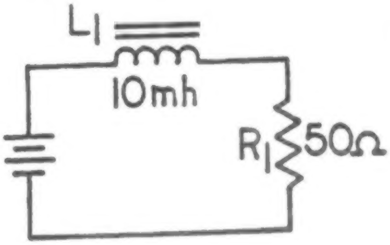
25.



Show work

26. Compute the inductive time constant utilizing the following circuit values.

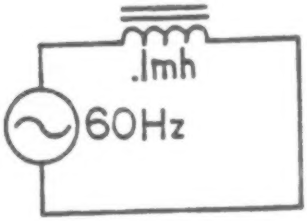
26.



Show work

27. Find X_L if the AC frequency is 60Hz and the circuit inductance is .1mh.

27.



Show work

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

TRANSFORMERS

1. A transformer consists of at least __________ coils of wire wrapped around an air or iron core. 1. ☐

2. The letter symbol for a transformer is __________. 2. ☐

3. Iron core transformers use a __________ core to reduce eddy current losses. 3. ☐

4. Draw the symbol for an iron core transformer. 4. ☐

5. The wire used in winding transformers and inductors uses __________ as an insulating material to prevent shorting of the coils. 5. ☐

6. The input winding of a transformer, which is usually connected to the source, is called the __________ winding. 6. ☐

7. The output winding of the transformer which is usually connected to a load, is called the __________ winding. 7. ☐

8. If the coils of a transformer are wound on a hollow cardboard or plastic form, the device is known as an __________ __________ transformer. 8. ☐

9. A transformer utilizes a process known as __________ induction to transfer energy from one winding to another. 9. ☐

10. As in the inductor, an expanding and __________ magnetic field allows for the operation of the transformer. 10. ☐

11. If a steady DC voltage were applied to the primary winding, would you expect a sustained output at the secondary? 11. ☐

12. A transformer has the ability to increase or decrease circuit (A)__________ or (B)__________. 12A. ☐ 12B. ☐

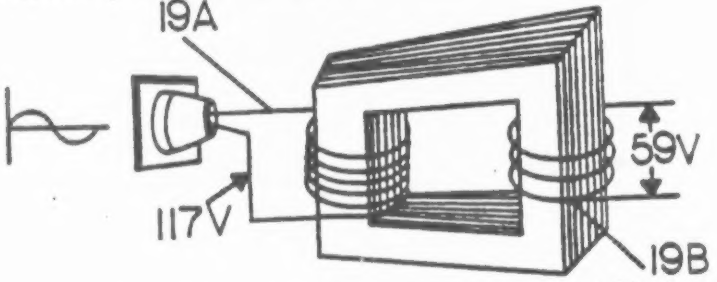
13. If a transformer reduces the input voltage, it is called a __________ transformer. 13. ☐

Name: ____________________

Date: ____________________

Period: ____________________

14.	A step-up transformer will increase the input voltage, but at the same time will __________ the available current.	14.	
15.	How does the input power and output power of a transformer compare?	15.	
16.	If the primary winding contains more turns of wire than the secondary winding, the the transformers will __________ voltage.	16.	
17.	The number of turns in the secondary of the transformer compared to the number of turns in the primary is described as the __________ __________.	17.	
18.	What is the phase relationship between the input and output voltage?	18.	
19.	Identify the windings in the transformer below:	19A.	
		19B.	



20.	Would the above transformer be classified as a step-up or step-down transformer?	20.	
21.	Observe the input wave applied to the transformer above. Draw a sketch of the output wave.	21.	
22.	Give the turns ratio formula which equates turns to voltage.	22.	
23.	If a transformer has a 4 to 1 turns ratio, it is classified as a __________ (step-up or step-down) transformer.	23.	
24.	A transformer has a 200 turn primary, and a 40 turn secondary, what is the turns ratio?	24.	
25.	If a transformer operates with a 10 volt input, has a 500 turn primary and 1000 turn secondary, then the secondary voltage is __________.	25.	

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

QUEST ACTIVITY

"UNIT 12"

1. Explain how an inductor reacts in a DC circuit?

2. How does an inductor react in an AC circuit?

3. Inductors oppose a change in __________ through the actions of an expanding or collapsing magnetic field.

4. List the common units for measuring inductance.

5. In a purely inductive AC circuit, what is the phase relationship between voltage and current?

6. List the basic formula for finding total inductance in a series circuit, and in a parallel circuit.

7. What is inductive reactance?

8. What is the formula for inductive reactance?

9. Define an inductive time constant.

10. Find the total inductance in the following problems: (Draw the circuit out; then solve the problem)

    A. Four inductors in series: 1mh, 8mh, 15mh, and 9mh.

Name: ____________________

Date: ____________________

Period: ____________________

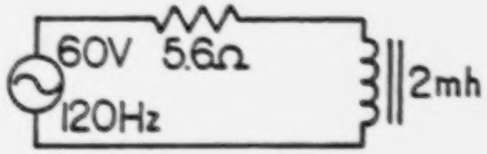
B. Two inductors in parallel: 18h, and 36h.

C. Two inductors in series: 6mh and 1h.

D. Three inductors in parallel: 6mh, 32mh, and 4mh.

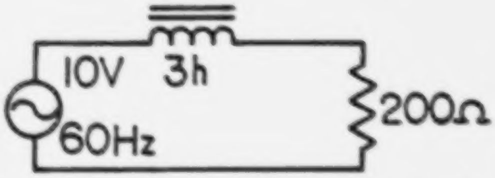
11. Find X_L in the following problems:

A.


60V
5.6Ω
120Hz
2mh

X_L = ____________________

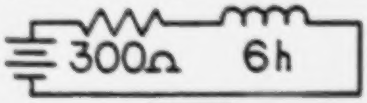
B.


10V
3h
60Hz
200Ω

X_L = ____________________

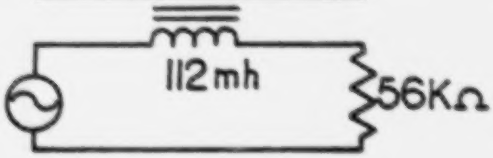
12. Find the time constant in the following problems:

A.



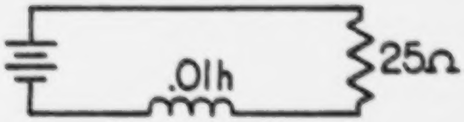
t = ____________________

B.



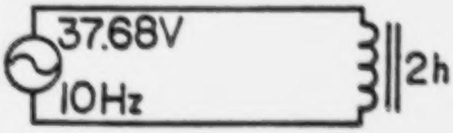
t = ____________________

C.



t = ____________________

13. Find the current flow in the following problem.


37.68V
10Hz
2h

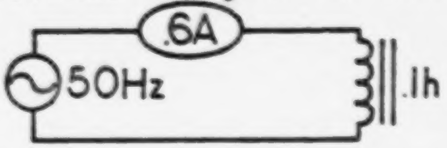
I = ____________________

Name: ______________________

Date: ______________________

Period: ______________________

14. Find the voltage in the following circuit.



E = ______________________

15. Can a transformer produce an output in a DC circuit? If so, when?

16. Does a transformer react to an AC input? Explain;

17. List the common ways of rating transformers.

18. What is the phase relationship between the input voltage and the output voltage of a transformer?

19. Explain the difference in purpose between the primary and secondary winding of a transformer.

20. Define the concept of mutual induction.

21. How does the power applied to the primary of the transformer compare to the power available at the secondary of the transformer?

22. List the power formula for transformers.

23. What is the difference between a step-up and a step-down transformer in reference to voltage?

Name: ________________

Date: ________________

Period: ________________

24. List the turns ratio formula for number of turns vs voltage.

25. If the primary winding of a transformer has 120 volts at .5 amps applied, and the secondary has a current flow of 1.5 amps what is the secondary voltage?

26. Solve the following transformer problems utilizing the proper formulas.

    A. E_p equals 50V; E_S equals 150V; I_S equals .250A; find I_p.

    B. N_p equals 1k; N_S equals 1.4k; E_p equals 117V; find E_S.

    C. N_S equals 500; N_p equals 150; I_p equals 3A; find I_S.

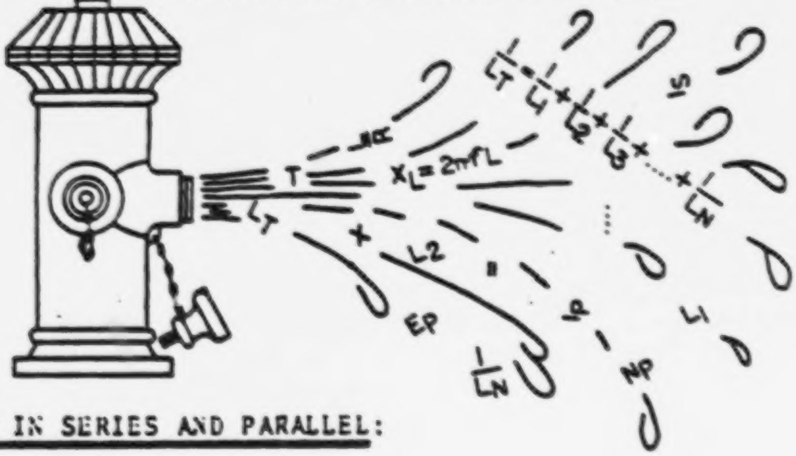
Name: ______________________

Date: ______________________

Period: ______________________

INFORMATIONAL HANDOUT

INDUCTOR AND TRANSFORMER FORMULAS



$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}$
IS
T
$X_L = 2\pi fL$
L_T
X
L2
EP
$\frac{1}{L_N}$
IP
NP
LI

INDUCTORS IN SERIES AND PARALLEL:

SERIES FORMULAS:

When inductors are connected in series the total effective inductance increases, thus L_T will always be larger than the largest "henry value" inductor in the series string.

Total Inductance $L_T = L_1 + L_2 + L_3 + \ldots + L_N$

Note the similarity of this formula to the series resistance formula.

PARALLEL FORMULAS:

Connecting inductors in parallel will decrease the total effective inductance, thus L_T will always be less than the value of the smallest "henry value" inductor.

Total Inductance - (Equal inductor values) $L_T = \frac{L}{N}$ $\frac{\text{inductance of one inductor}}{\text{number of inductors}}$

- (Two inductors unequal value) $L_T = \frac{L_1 \times L_2}{L_1 + L_2}$

- (General formulas) $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}$

$$L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}}$$

Note the similarity of these formulas to the parallel resistance formulas.

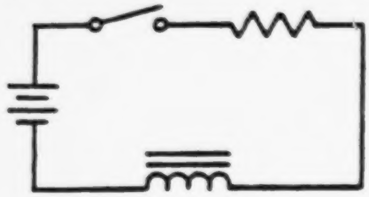
Name: ____________________

Date: ____________________

Period: ____________________

R-L TIME CONSTANT:

An R-L network contains a resistor and an inductor connected in series with a DC source. This circuit will cause the current to change gradually between zero and maximum when the circuit is energized, and to fall gradually from maximum to zero when the circuit is switched off.



The rate at which the inductor allows current to flow through the circuit depends upon the inductance and resistance present in the circuit. The higher the inductance, or the lower the resistance, the slower the change in current flow.

TIME CONSTANT FORMULA:

$T = \frac{L}{R}$

Where T = time in seconds

L = inductance in henrys

R = resistance in ohms

One time constant (1T) is the time required to allow 63.2% of maximum current to flow through the circuit.

INDUCTIVE REACTANCE:

Inductors act as a simple resistance in a DC circuit, once current flow has stabilized, but in an AC circuit, the inductor poses a peculiar opposition to the flow of AC current. This opposition to AC current is called inductive reactance and is dependent upon frequency and inductance.

FORMULA:

$X_L = 2\pi f \times L$

Where X_L = inductive reactance in ohms

2π = 6.28, a mathematical constant

f = frequency in hertz

L = inductance in henrys

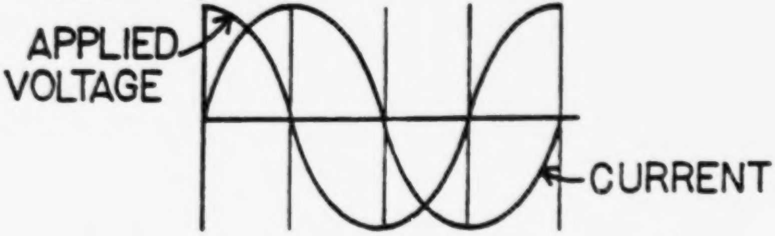
Name: ____________________

Date: ____________________

Period: ____________________

INDUCTIVE PHASE RELATIONSHIPS:

In a purely inductive AC circuit the applied voltage leads the current by 90°.



TRANSFORMER TURNS RATIO FORMULAS:

A transformer utilizes the principle of mutual induction to transfer energy from the primary to the secondary winding of the transformer. This transfer of energy is dependent upon the number of turns of wire in the primary and secondary coils. This relationship between primary and secondary turns is called the "turns ratio", and can be used to describe turns vs voltage vs current relationships.

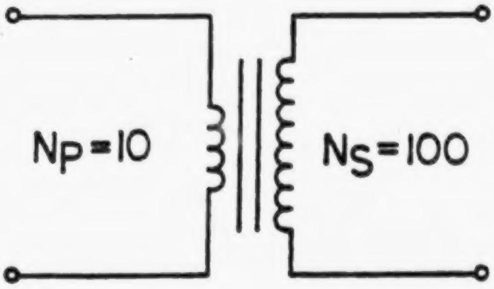
TURNS RATIO FORMULA:

Turns ratio is a comparison of the number of turns in the secondary to the number of turns in the primary.

$$\text{Turns ratio} = \frac{N_s}{N_p} \text{ or } N_s : N_p$$

Where N_s = number of turns in secondary

N_p = number of turns in primary



The turns ratio for the above transformer then, is $\frac{N_s}{N_p} = \frac{100}{10} = \frac{10}{1}$ or 10:1. This information says that for an input of say 20V in the primary, then we would expect a secondary output of 200 volts.

Name: ____________

Date: ____________

Period: ____________

VOLTAGE RATIO:

Assuming a transformer has unity coupling, such as a power transformer, the following formula holds true.

$$\frac{E_s}{E_p} = \frac{N_s}{N_p}$$

Where E_s = secondary voltage

E_p = primary voltage

N_s = number of turns in secondary

N_p = number of turns in primary

Knowing any three terms, you can solve for the unknown fourth term.

CURRENT RATIO:

In a like manner primary and secondary currents and turn ratio can be equated or compared as follows:

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

Again, knowing any three terms will allow you to solve for the remaining term.

TRANSFORMER POWER RELATIONSHIP:

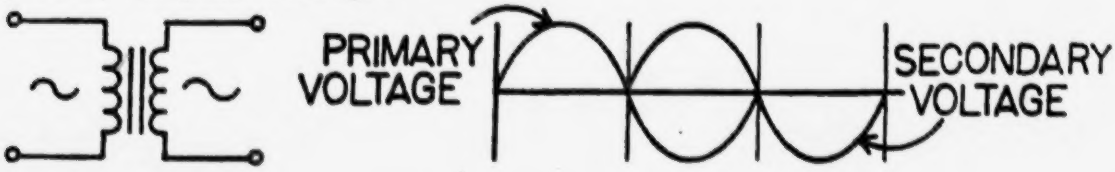
Recall, electrical power can be found by multiplying E times I. In a transformer, energy in the form of a varying voltage and current enters or is applied to, the primary winding, forming a pulsating magnetic field which transfers energy to the secondary by mutual induction. You will find that the power input and the power output in a transformer has a direct relationship. In fact, the input power equals the output power.

Thus. $I_p \times E_p = I_s \times E_s$

TRANSFORMER PHASE RELATIONSHIPS:

Primary versus secondary voltage interaction.

The induced voltage in the secondary is 180° out of phase with the primary (input) voltage.



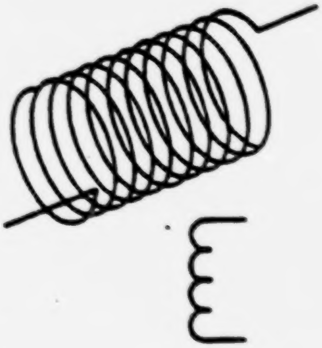
Name: ______________

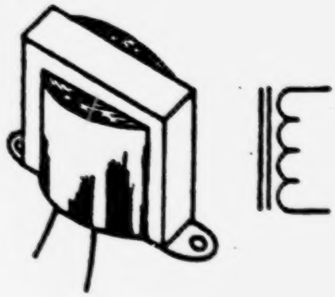
Date: ______________

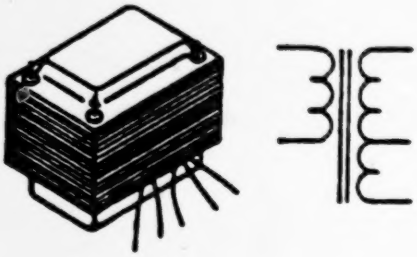
Period: ______________

INFORMATIONAL HANDOUT

INDUCTORS/TRANSFORMERS - WHAT THEY ARE AND HOW THEY FUNCTION







INDUCTORS

GENERAL INFORMATION:

In its basic form, the inductor is a coil that has an inductance value that is determined by a number of specific factors. The most essential of these are:

- The number of turns in the coil.
- The total length of the coil.
- The cross-sectional area of the coil/core.
- The permeability of the core material.

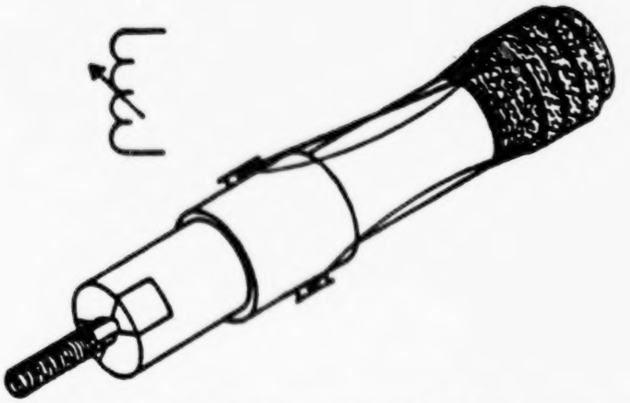
There are formulas for calculating the inductance of various types of coils, and utilizing these formulas, one can design a coil to have any desired value. Inductors are generally either iron-core or air-core and sometimes are referred to as "chokes" or "reactors".

Inductors are available in both fixed and variable form, with the latter used principally in high-frequency circuits only. The position of the core within a variable inductor can be adjusted by threading the core, using an adjustment tool, and positioning it such that the required inductance is set.

Name: ____________________

Date: ____________________

Period: ____________________



Rating: Iron-core inductors are rated in terms of INDUCTANCE, RESISTANCE, AND CURRENT CAPACITY.

Radio-frequency chokes are rated in terms of INDUCTANCE, QUALITY FACTOR, AND OPERATING FREQUENCY.

Quality factor "Q" is a measure of a coil's quality and this refers to the ratio of its inductive reactance to its DC resistance at a specific frequency.

$$Q = \frac{X_L}{R}$$

Capacity: The basic electrical value of an inductor is the henry, however, you may encounter millihenries (mh) or microhenries (µh) as the designated rating on a given component. You can convert millihenries into henries and vice-versa simply by moving the decimal point 3 digits to the left or right as appropriate. For example, .007h is the same as 7mh. Note, many times the value is not printed directly on the inductor or coil and the system of identification is sometimes difficult at best! Good Luck.

USES FOR INDUCTORS:

After all this discussion on inductors, it might be a good idea to find out what they are used for. The inductor is a versatile device and can be used to perform a number of different circuit functions. Inductors are generally utilized in a wide array of tuning and filter circuits, lets look at some circuit usage.

- ○ Iron-core inductors are used in circuits where the frequencies are in the audio range (20-20khz).
- ○ Air-core and ferrite-core inductors used in circuits above 20 kilohertz.
- ○ Generally, high frequency inductors are used with capacitors to form tuned (resonant) circuits which allow you to select or reject signals.

Name: ____________________

Date: ____________________

Period: ____________________

TRANSFORMERS

GENERAL INFORMATION:

In its basic form, the transformer consists of two coils electrically insulated from each other, yet generally wound upon the same core and interacting magnetically. Magnetic coupling is used to transfer electrical energy from one coil to another. The coil that is connected to an AC source of energy is called the PRIMARY WINDING, and the coil to which energy is transferred is called the SECONDARY WINDING. Remember that in some transformers there may be more than one secondary winding. Sometimes the secondary winding also contains a special connection at a given point to provide a different output, this is referred to as a tap. Now, when you have on a schematic, the reference "CT," immediately think .... center-tapped connection, which means divide the output voltage in half.

Type: Transformers can be usually classified as either power or audio variety. Note, sometimes the abbreviation "XMFR" is used to indicate the term transformer.

POWER XMFR = a device which can obtain different (step-up or step-down) voltages from a typical AC power line.

AUDIO XMFR = a device which allows coupling of signals from one stage to another.

At this point you should be aware of two other types of special transformers that you may encounter in typical electronic work. Look at these!!!!!

AUTOTRANSFORMER = a device like a power transformer, however it consist of a single winding that is tapped to provide the necessary step-up or step-down function.

ISOLATION XMFR = a device not generally concerned with the step-up or step-down function, but instead serves as a safety device by isolating the ground conductor of the power line from a chassis.

Note! Power transformer cases (frame) are made of metal and can add considerably to the overall weight of the device and should be considered when designing parts layout.

Rating: Power XMFR - specification given are generally the primary's operating voltage and/or frequency, and the secondary's output voltage and maximum current. Transformer leads are sometimes color coded or the specifications are located on the XMFR case, but this is not consistently done so if necessary refer to an appropriate reference. A typical rating might read as follows: PRI., 120V, 60Hz; Sec., 300V CT at 50MA; 6.3V CT at 3A.

Name: ____________________

Date: ____________________

Period: ____________________

Audio XMFR - specifications given are generally the primary and secondary impedance. Don't forget that most electronic stores sell this kind of transformer with the schematic diagram code attached either on a piece of paper or on the box itself so do not discard it before checking placement. A typical rating might read as follows: Primary impedance (Z) 100K , Secondary impedance (Z) 2.5K .

TRANSFORMER SAFETY:

Power transformers can be very DANGEROUS!!! Especially since they often have one high voltage winding. This device can present a severe shock hazard so extreme care must be observed when testing for voltages or working in the power supply stage of a piece of equipment. Remember ..... "a misplaced finger can result in a real tingler"!!!

TRANSFORMER TESTING:

Transformers can suffer from the same problems or defects that occur in many electronic components so you can apply all previous "troubleshooting" experience when working with transformers or, for that matter, inductors.

When checking transformers, be on the look out for:

- Shorts between windings
- Excessive current flow
- Grounded windings (shorts between the windings and the core or frame)
- Internal shorts between turns

Kinds of tests: Generally a continuity check is able to determine an open winding which may exist within the transformer, however, continuity between windings indicate a shorted condition. CAUTION!! When taking continuity measurement power is turned off.

Many technicians like to run a performance test on transformers; which means apply a known voltage to the primary winding and observe the secondary voltage for the proper reading.

USES FOR TRANSFORMERS:

The principal application of this component can be simply stated, a device that utilizes mutual inductance to transfer electrical energy (AC) from one circuit to another. Its application then must be based on this specific ability and the needs of a circuit. Hence you will find that this component is widely used in power supplies, amplifiers, power distribution systems, consumer products, etc.

INFORMATION SUMMARY – TRANSFORMERS.

The operation of a transformer depends on the principle of electromagnetic induction. A transformer consists of two or more inductors, physically placed so that the magnetic field from one inductor (or winding) induces a voltage in another or other windings. Therefore, mutual inductance exists between the two windings and they are said to be inductively coupled.

Figure 1 shows a basic trnasformer circuit consisting of a transformer connected between a generator and a load. The coil connected to the source is the primary winding, and the coil connected to the load is the secondary winding.

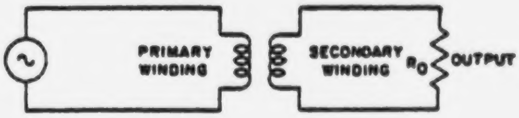


Figure 1
Basic transformer

Although no direct physical connection exists between the secondary and primary, the connection that does exist is in the magnetic flux field between the two inductors. Thus power is effectively transferred by induction.

In a perfect transformer, all of the energy from the source is delivered to the primary. All of the power in the primary is converted into lines of flux. Therefore, we can say that the power in the primary is equal to power in the secondary or $P_p = P_s$.

For maximum transfer of power to occur, all the lines of force from the primary must intercept the secondary. To do this, the secondary winding is very often wound on top of the primary with only insulation separating the two.

Information Summary (cont'd)

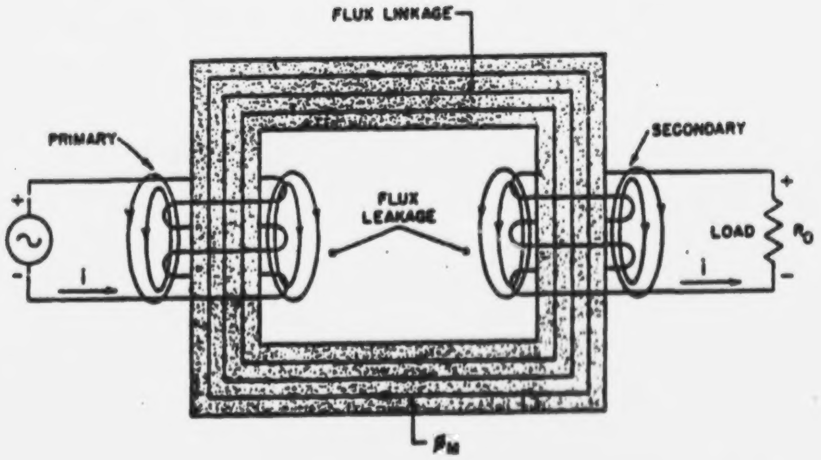


Figure 2
Iron-core transformer.

To further accomplish maximum power transfer, a soft-iron core is introduced. Even with the use of high permeability cores, a few of the flux lines do not cut the secondary. This represents a flux leakage and a power loss. See Figure 2. In a well designed transformer, this loss is kept down around 2 percent.

The opposite of flux leakage, the percent of primary lines that are doing work, is called co-efficient of coupling. The coefficient of coupling for a quality transformer will be around 98% or 0.98. This means that 98 out of 100 lines generated by the primary will cut the secondary winding.

Information Summary (cont d)

Figure 3 shows a shell type core which is the most efficient core. Note the manner in which the coils are wound and the manner they are insulated from each other.

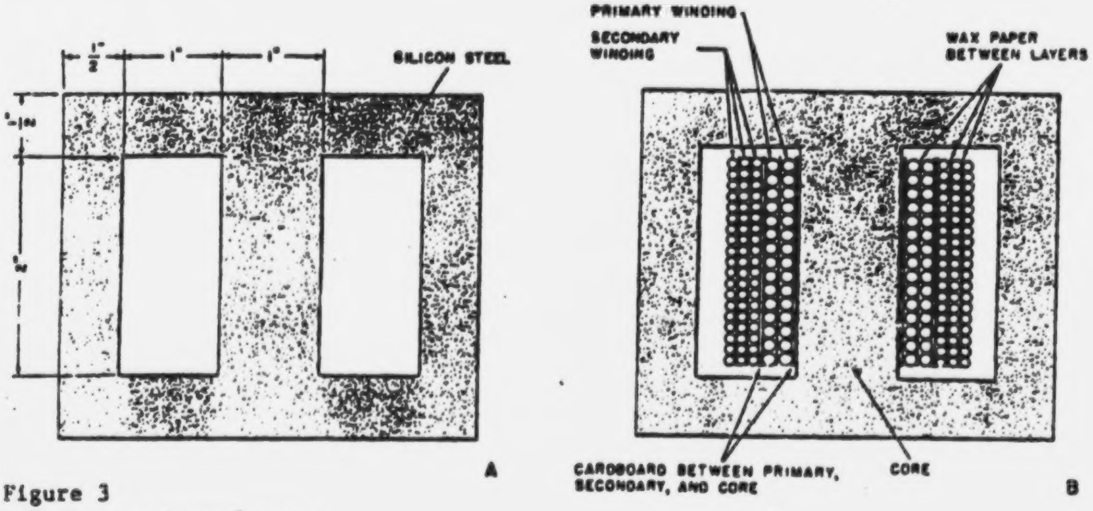

1"/2
1"
1"
SILICON STEEL
A
PRIMARY WINDING
SECONDARY WINDING
WAX PAPER BETWEEN LAYERS
CARDBOARD BETWEEN PRIMARY, SECONDARY, AND CORE
CORE
B

Figure 3
Iron core transformer.

The following is a step-by-step explanation of the voltages and currents occuring in a transformer. Be sure you fully understand inductance before you attempt this package. Refer to Figure 4, A and B for the following.

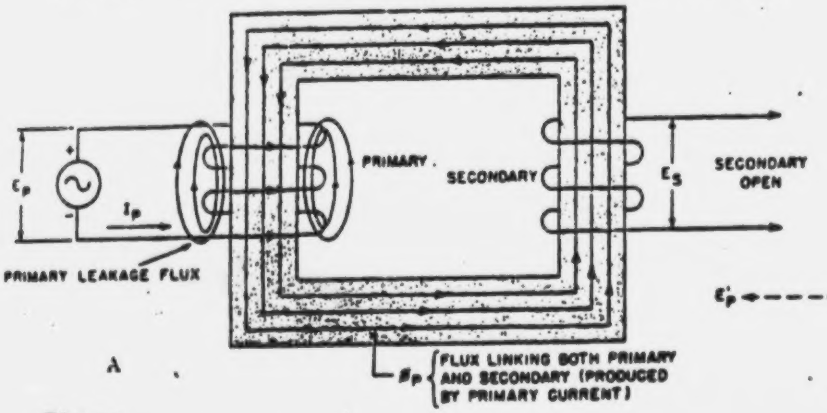
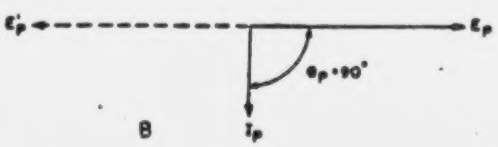

E_p
+
-
I_p
PRIMARY LEAKAGE FLUX
PRIMARY
SECONDARY
E_S
SECONDARY OPEN
A
ϕ_p {FLUX LINKING BOTH PRIMARY AND SECONDARY (PRODUCED BY PRIMARY CURRENT)

Figure -
Cross section of iron-core trnasformer.


E_p'
E_p
$\theta_p = 90°$
B
I_p

Directions of flux lincs produced by primary current.

Information Summary (cont'd)

Figure 4A shows a simple transformer across the output of a generator. The secondary has no load. This open circuit will allow us to ignore the secondary currents which cannot flow in an open circuit. (These currents have a large effect on the primary when they do flow.) This makes the primary, in effect, is a large inductor. Looking at Figure 4B, you will see a vector diagram of the primary voltage and current. This large inductor will offer inductive reactance to the generator. This causes the following situation in the primary.

The generator will apply a voltage, Ep, across the primary coil. This voltage will cause a current to flow that is 90° out of phase with the generator voltage; this is simply an inductive reactance. This current, Ip, will in turn set up a voltage, Ep, that is 90° out of phase with the current that created it. This voltage, Ep, is then 180° out of phase with the source voltage Ep.

Now let's look at the effect of this primary action on the secondary. See Figure 5.

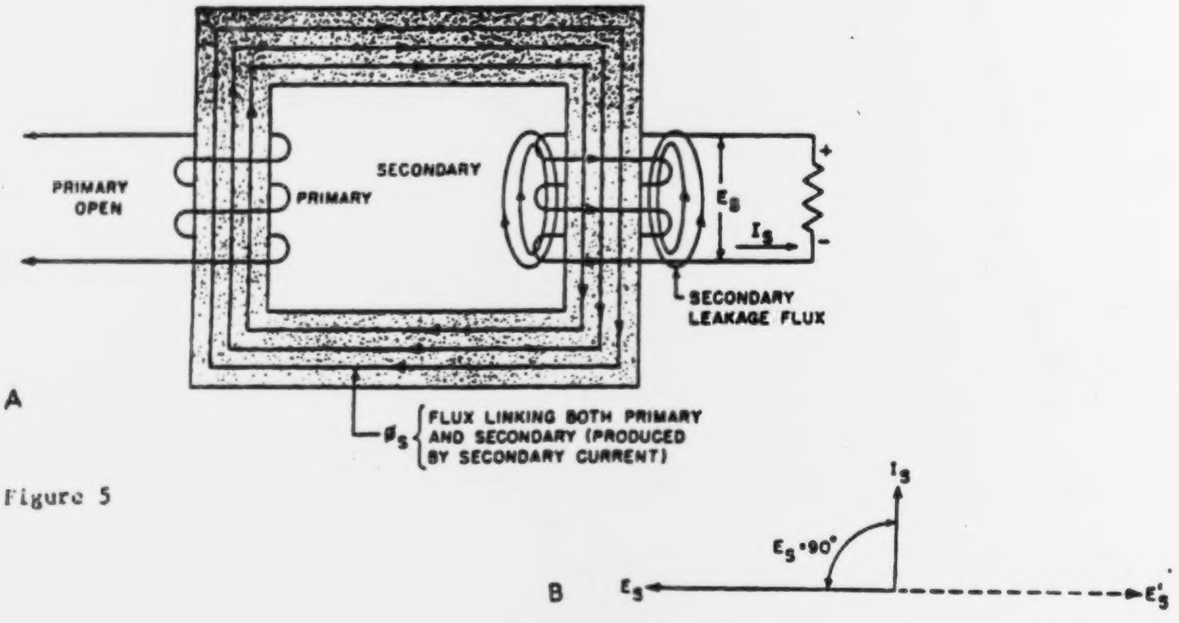

PRIMARY OPEN
PRIMARY
SECONDARY
E_S
I_S
+
-
SECONDARY LEAKAGE FLUX
A
ϕ_S FLUX LINKING BOTH PRIMARY AND SECONDARY (PRODUCED BY SECONDARY CURRENT)
I_S
E_S • 90°
B
E_S
E'_S

Figure 5

Information Summary (cont'd)

For ease of explanation the action taking place in the primary will not be shown. However, keep in mind that it is taking place at the same time. So that we can see what takes place, a resistance has been added to the secondary allowing a small current to flow. If we consider the secondary alone, we realize that it is a simple inductance in which a voltage has been induced by the lines of flux from the primary. This voltage has the same phase as the CEMF (Ep) of the primary. A good way of looking at the secondary is to treat the induced voltage as a generator in series with an inductor. If we do this, we see that the current through the secondary and the voltage across it are 90° out of phase. Note Figure 5B.

To conform to the law that energy can neither be created nor destroyed, the following is what must take place. The lines of flux set up by the secondary current are in opposition to the lines of flux created by the primary. Any increase of secondary current causes a decrease in primary flux. Since this is true, and we are dependent upon the flux for the primary/secondary connection, the primary current must then increase. This further reinforces the fact that power in the primary is essentially equal to the power in the secondary.

Another way to consider secondary effect on the primary is to use vector diagrams (see the dotted lines in Figure 5B). The current in the secondary has two effects; (1) it sets up a counter EMF in the secondary that is 180° out of phase with secondary voltage, (2) it sets up a voltage in the primary that is in phase with this CEMF. The net result of this is that the voltage induced in the primary by the secondary current is in phase with Ep and 180° out of phase with Ep. This has the effect of reducing the CEMF of the primary which allows more current to flow. So again, the power in the primary is essentially equal to the power in the secondary.

Information Summary (cont'd)

So far we have considered the transformer as two separate pieces. Now it is time to put them all together. Refer to Figure 6 for the following.

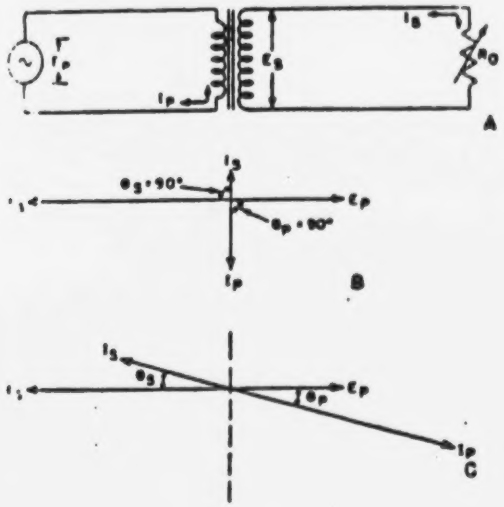


Figure 6
Phase relationships of voltage and current in a transformer.

The conditions are as follows: There is a small current flowing in the circuit shown in A. The vector diagrams are as shown in B. Voltages across the transformer are 180° out of phase as are the currents. The phase angle between current and voltage in the primary is 90° with current lagging. The same applies to the secondary. As the resistor is decreased, current (the load) in the secondary increases. This means that resistive current increases and the current and voltage in the secondary approach an in-phase condition. At the same time, this increasing secondary current causes and increase in primary current which makes the primary appear more resistive. This condition causes the primary voltage and current to approach an in-phase condition. Part C shows the vector diagram for this condition.

If we could construct an ideal transformer, the voltage and current vectors would be super-imposed and with the secondary voltage and current 180° out of phase.

Information Summary (cont'd)

This would provide a perfect transfer of power and the generator would see only the resistive load.

Voltage Turns Ratio

Due to transformer action we may predict the voltage induced in the secondary by using the applied voltage and the turns ratio. Thus we can say that $\frac{Ep}{Np} = \frac{Es}{Ns}$.

Where: Ep = applied voltage to primary
Np = number of primary turns
Es = induced secondary voltage
Ns = number of secondary turns

We can rewrite the above equation in forms such as:

$$EpNs = EsNp \text{ or } Es = \frac{EpNs}{Np}$$

Keep in mind that the resulting voltage going from primary to secondary can increase or decrease. But this step-up or step-down applies only to voltage.

Another method of predicting secondary voltage is to use the volts per turn value. Since this number is the same for both the secondary and primary, it is a valid tool. Thus volts/per turn is equal to $\frac{Ep}{Np}$.
To compute the secondary voltage we need only take the volts per turn number and multiply it by Ns to arrive at the secondary voltage. This volts per turn method applies no matter how many secondary windings there are.

There are other methods for determining the ratios of transformers such as power and current. To fully understand them, you should use your reference library.

Transformer Losses

There are four main types of losses in transformers. There are hysteresis, saturation, eddy currents, and copper losses.

Information Summary (cont'd)

The hysteresis loss is the loss of magnetic energy used to magnetize and demagnetize the core.

The saturation loss occurs when the core can no longer accept more lines of flux.

Eddy current loss applies to the small short circuits inherent in cores.

Copper loss relates to the loss due to the DC resistance of the windings.

INFORMATION SUMMARY - INDUCTIVE REACTANCE

1. When AC flows through an inductor, an opposition to current flow results from the self-induced voltage across the coil. This opposition to current flow is called inductive reactance.

2. The formula which is used to calculate inductive reactance is $X_L = 2\pi fL$

X_L = indicates a reactance which is measured in ohms
2π = is a constant factor from which a sine wave derived 2π radians = 360°
f = frequency is a time element measured in Hz.
L = inductance measured in Henrys

3. The X_L formula points out two major points

a. X_L is directly proportional to frequency.
b. X_L is directly proportional to inductance.

When working with the reactance formula, you will find it useful to solve for L and f.

example:

$$L = \frac{X_L}{2\pi f} \qquad f = \frac{X_L}{2\pi L}$$

The above formulas are used in many different circuit calculations involving inductive reactance.

4. Resistance in series circuits are combined to find the total resistance. Series reactances are found the same way for example:

$$X_{LT} = X_{L1} + X_{L2} + X_{L3}$$

Total reactances in parallel is calculated by the reciprocal formula.

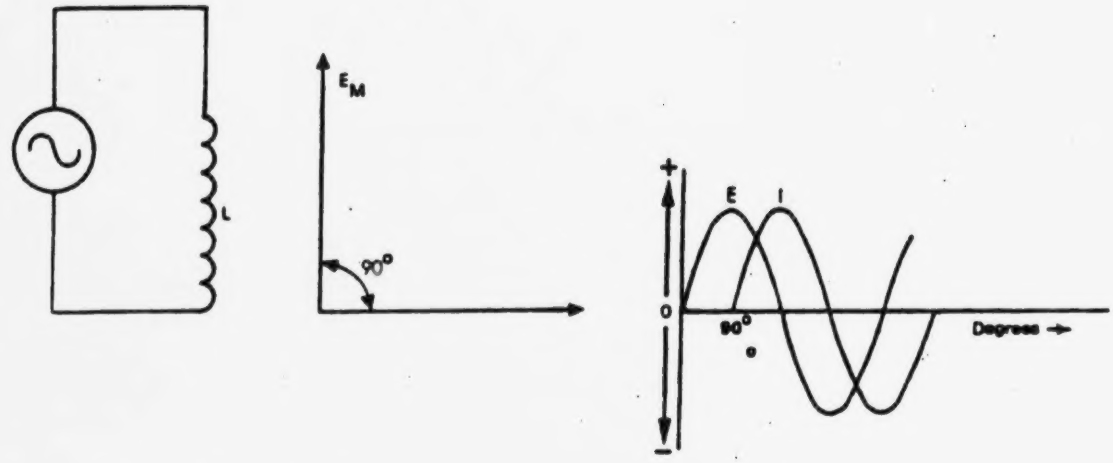
$$X_{LT} = \frac{1}{\frac{1}{X_{L1}} + \frac{1}{X_{L2}} + \frac{1}{X_{L3}}}$$

5. Inductive reactance and current in an inductive circuit with negligible resistance can be found by using Ohms Law.

$$I = \frac{E_L}{X_L} \quad \text{or} \quad E_L = I_1 \times X_L \quad \text{or} \quad X_L = \frac{E_L}{I}$$

Information summary continued.

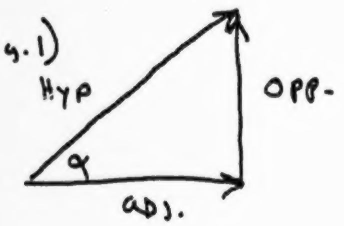
6. Inductance in an AC circuit is the property which will oppose a change of current. This opposition will cause the current to lag the voltage by nearly 90 degrees. This lag can never reach 90° because there is always resistance present in the circuit.



Current lags voltage by 90° in a lossless circuit.

NAME ____________________
DATE ________ PER ________

1.] Write formula for the following (fig.1)


HYP
OPP.
α
ADJ.

a. sin α =

b. cos α =

c. tan α =

Fig 1

2.] Given: formula "a." (fig 2

a. Solve for: sin α

b Solve for: α

c. Solve for cos α

D. Solve for α

E Solve for tan α

F. Solve for α

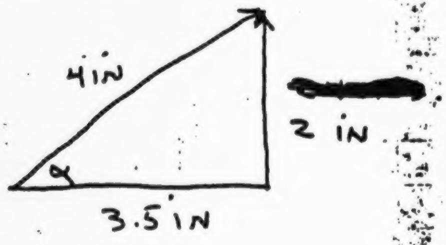

4 IN
[redacted]
2 IN
α
3.5 IN

Fig 2

---

3. Given: Angle in fig. 3

a. Solve for [redacted] sin α

b. Solve for X

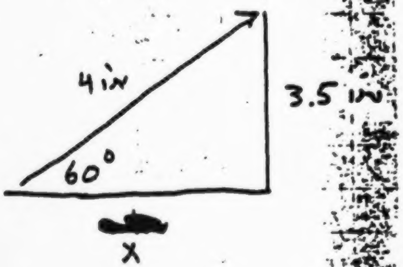

4 IN
3.5 IN
60°
[redacted]
X

Fig. 3

FORMULAS Chap. 13

SELF INDUCTANCE

$$L = V_L \times \Delta t / \Delta i$$

$$L = \mu_r \times \frac{N^2 \times A}{l} \times 1.26 \times 10^{-6}\ H$$

$$V_L = L\ \Delta i / \Delta t$$

TRANSFORMERS

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$N_p = \frac{V_p N_s}{V_s}$$

$$N_s = \frac{V_s N_p}{V_p}$$

$$V_p = \frac{N_p V_s}{N_s}$$

$$V_s = \frac{N_s V_p}{N_p}$$

$$\left(\frac{N_p}{N_s}\right)^2 = \frac{Z_p}{Z_s}$$

$$\frac{N_p}{N_s} = \sqrt{\frac{Z_p}{Z_s}}$$

$$Eff = P_{out} / P_{in}$$

$$^{*}\ \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

* ONLY TRUE WHEN TRANSFORMER EFFICIENCY

PROBLEM SHEET ______ INDUCTANCE

1.

Solve for the following Values
Show formula, Values, Answer

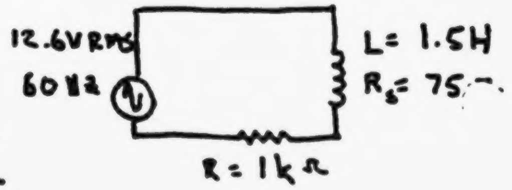

12.6VRMS
60HZ
L= 1.5H
R_S= 75 Ω
R= 1kΩ

fig. 1

X_L = ______________________________
Z = ______________________________
I_{rms} = ______________________________
V_R = ______________________________
V_L = ______________________________
∠° = ______________________________

VECTOR DIAGRAM

2

Solve for the following Values

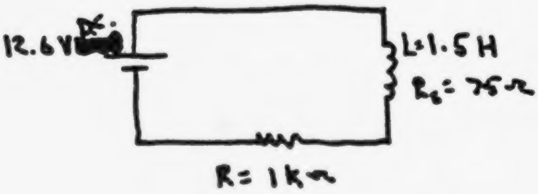

12.6V DC
L=1.5H
R_S= 75Ω
R= 1kΩ

fig. 2

V_L =
V_R =
I =

How does "I" in problem #2 compare with "I" in PROBLEM #1? ______________________

why?. ______________________________

____

____

3.

Solve for L = ☐

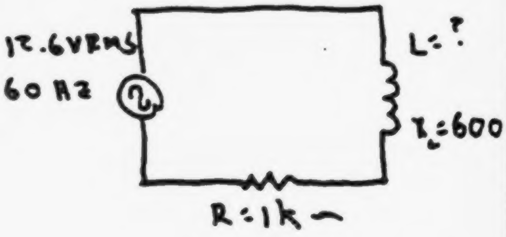

12.6VRMS
60 HZ
L= ?
X_L=600
R=1kΩ

fig 3

4 Solve for the following Values

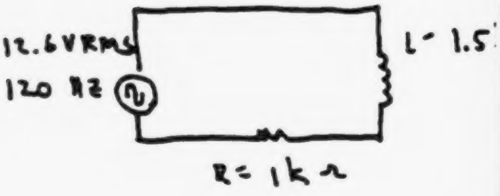

12.6VRMS
120 HZ
L= 1.5
R= 1kΩ

fig 4

I_{rms} = ______________________________
∠° = ______________________________

NAME ____________
DATE ______ PER ______

1. Draw a parallel RL circuit across an AC power source of 100VAC p-p. Label $X_L = 50\Omega$ and $R = 50\Omega$

Fig 1

2. Draw a vector diagram for this circuit. See text pg. 401

3. Solve for I_R (Place value on Vector)

Diagram

____________ formula ____________ calculations ____________ answer

4. Solve for I_L (Place Value on Vector)

____________ formula ____________ calculations ____________ answer

5. Solve for I_T (Place value on Vector)

____________ formula ____________ calculations ____________ answer

6. Solve for Circuit Z

____________ formula ____________ calculations ____________ answer

7. What is common in Parallel Circuits? ____________

8. What is true about Circuit Z in Parallel Circuits?

____

NAME ______________________

DATE ______________ AM/PM

1. DRAW A SERIES R L CIRCUIT
ACROSS AN AC POWER SOURCE
OF 10VAC p-p

2. Label $X_L = 1.2k$, $R = 500\ \Omega$

Fig. 1

3. DRAW A VECTOR DIAGRAM
for this circuit.

DIAGRAM

4. Solve for the phase α
(SHOW FORMULA USED)

Formula ______ Calculations ______ ANSWER ☐

5. Solve for circuit Z
(USE X_L & R)

Formula ______ Calculations ______ ANSWER ☐

6. Solve for circuit Z
(USE phase α)

Formula ______ Calculations ______ ANSWER ☐

7. Solve for E_L (USE phase α)

Formula ______ Calculations ______ ANSWER ☐

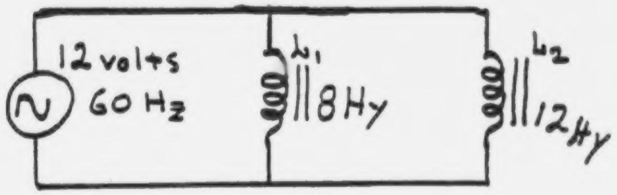
8. Solve for E_R (USE phase α)

Formula ______ Calculations ______ ANSWER ☐

Electronics 30 Homework 9

Grob 5th edition -----> Review chapter 18 (last assignment) Do problems 1 thru 16 on page 307. Also read chapter 19 and do problems 1 thru 17 on pages 385 and 386
or -
Grob 4th edition -----> Review chapter 19 (last assignment) Do problems 1 thru 16 on pages 392 and 393. Also read chapter 20 and do problems 1 thru 17 on pages 412 and 413

1.


12 volts
60 Hz
L_1
8 Hy
L_2
12 Hy

FIND:

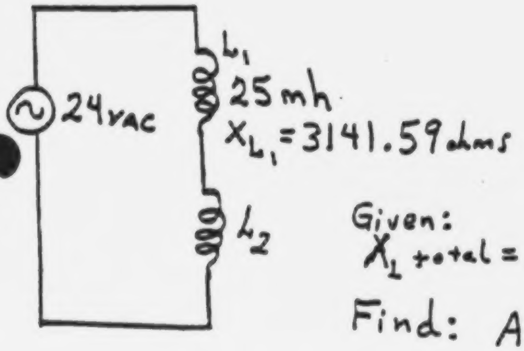
$X_{L_{total}}$ ________ ohms

I_{L_1} ________ ma

L_{total} ________ Hy

X_{L_2} ________ ohms

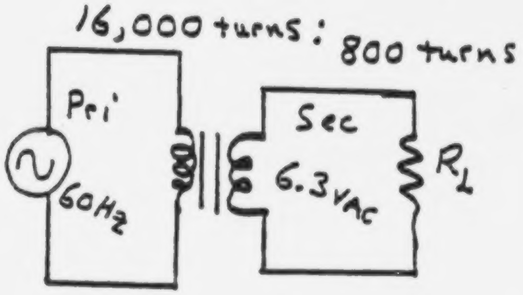
2.


24 VAC
L_1
25 mh
X_{L_1} = 3141.59 ohms
L_2

Given:
X_L total = 8168.14 ohms

Find: Applied frequency ____ KHz
L_2 inductance ________ mh

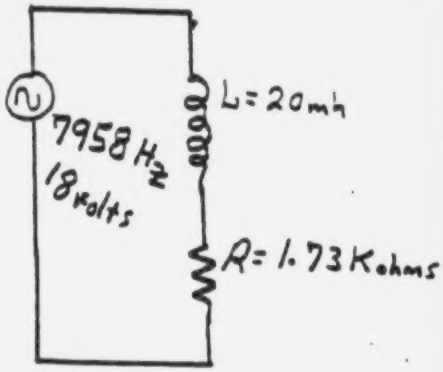
3.


16,000 turns : 800 turns
Pri
60 Hz
Sec
6.3 VAC
R_L

Given: Z primary is 35.7 K ohms
after considering an 85%
transformer efficiency factor.

FIND: R_L ________ ohms

4.


7958 Hz
18 volts
L = 20 mh
R = 1.73 K ohms

Find:

Z ________ K I ________ ma

θ ________ ° p.f. ________

V_{X_L} ________ v V_R ________ v

True Power ________

EXPERIMENT

Experiment #1

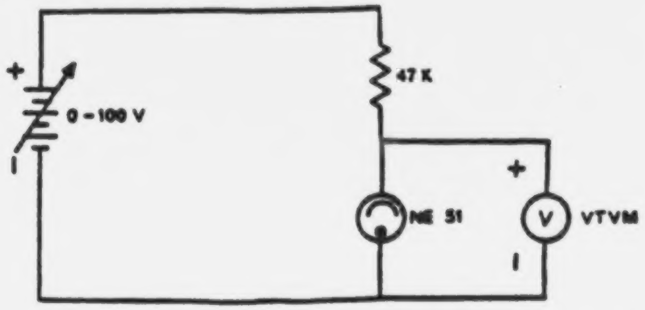
SELF INDUCTANCE

MATERIAL AND EQUIPMENT:

High voltage power supply, about 100 V
Low voltage power supply, about 12 V
4 to 10 H choke
NE 51 or NE 2 or similar neon tube
47 K resistor (approximately)

PROCEDURE:

1. Connect circuit as shown.

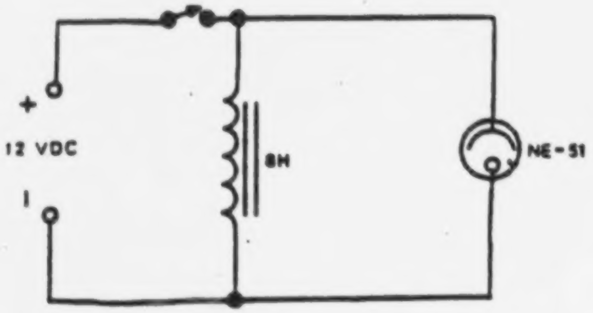


2. Increase power supply volts until neon bulb glows.
3. Use the VTVM to measure the voltage across the neon bulb.

RECORD VOLTAGE __________________

NE 51 bulb should glow at 65 V and up.

4. Connect circuit as shown.



Experiment #1 continued.

5. Adjust power supply to read 12 VDC.
6. Connect negative side of power supply to the circuit.
7. Take the positive lead from the power supply and touch the positive side of the circuit.
8. Observe the neon bulb very closely when you close and then open the circuit.
9. Describe what happened:

10. Observe step 3 and notice that the voltage required to make the neon bulb glow is much greater than 12 VDC.
11. Observe step 8 and notice this same neon bulb will glow if only momentarily with only 12 V applied.

This experiment verifies that a high self induced or counter EMF, (CEMF) appears across the coil when the circuit is opened and this induced voltage fires the neon bulb. This CEMF is sometimes called inductive kick. An application of inductive kick is found in automotive ignition system where the coil must supply 15,000 - 20,000 volts to fire the spark plugs when using only the 12 volt car battery voltage!

EXPERIMENT

Experiment #2

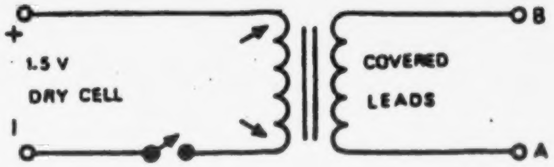
MUTUAL INDUCTION

MATERIALS AND EQUIPMENT:

1½ V battery
Switch Spst.
Output transformer, or one with a large turn ratio.

PROCEDURE:

1. Set up circuit as shown.



2. Connect output transformer with bare leads (output) going to the switch and voltage source.
3. To demonstrate that mutual induction exists between two coils, touch points A and B with both hands.
4. Then have a friend close this switch.
5. Open the switch with the circuit complete. What happened?

6. At which point, the closing of the switch or the opening of the switch, was the result most noticeable?

Experiment #2 continued.

7. Explain why.

8. How is the energy transferred from primary to secondary?

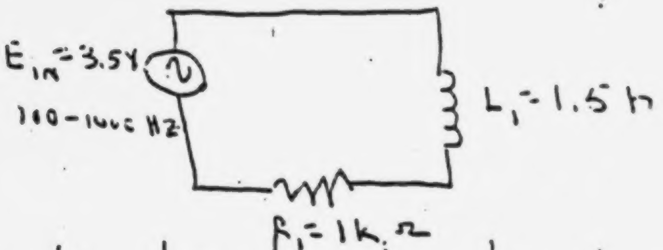
The results of this experiment should verify to you that a changing current in one coil can induce voltage in another coil.

Exp. #3 Lab Report

Date ________ Per ____

Unit: Inductance

Purpose: To demonstrate the relationship of inductive reactance to frequency



$E_{in} = 3.5V$
100-1000 Hz
$L_1 = 1.5$ h
$R_1 = 1k\ \Omega$

									MEASURE		
FREQ. IN Hz	E_{IN} RMS	R	X_L	Z	∠°	I ma	V_R	V_L	I	V_R	V_L
100											
200											
300											
400											
500											
600											
700											
800											
900											
1000											
			$_L = 2\pi f L$	$= \sqrt{X_L^2 + R^2}$	$\tan\angle = X_L/R$	$I = E_{in}/Z$	$_R = I \cdot R$	$_L = \sqrt{V_Z^2 - V_R^2}$			

Pg. 2

Unit: Inductance
: Exp. #3

Questions

1. As freq. increases what happens to X_L?
(increase / decrease)

2. As X_L increases what happens to the circuit impedance? (incr. / decr.)

3. As the freq. increases X_L (incr / decr) the Z (incr / decr) and the phase ∠ (incr / decr)

4. What does the phase ∠ of the circuit mean to you? ______________________

____

____

5. How do your measured values compare to your calculated values?

V_L meas. ________ calc ________

V_R meas. ________ calc. ________

I meas. ________ calc. ________

6. What did you learn from this experiment?

1. ______________________

____

2. ______________________

____

3. ______________________

____

4. ______________________

____

EXPERIMENT 3

MATERIALS AND EQUIPMENT

audio generator, 100 to 500 ohm resistor
5 to 15 henry choke, and an AC voltmeter

PURPOSE:

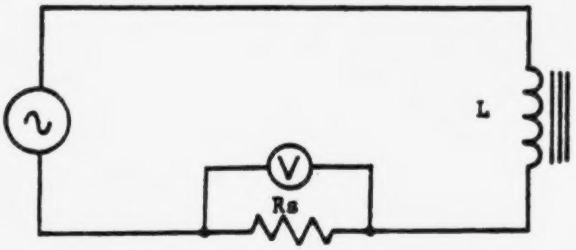
To demonstrate the relationship of Inductive Reactance to frequency.

OBJECTIVE:

When you have finished this experiment, you will be able to answer some questions about inductive reactance and frequency.

PROCEDURE:

1. Connect the circuit as shown and adjust the generator for 10 volts AC at 100 hz. Maintain this voltage during the experiment.



2. Adjust the frequency of the audio generator to the values shown in the table. Measure the voltage drop V_R across the resistor for each frequency and enter this value in the table.

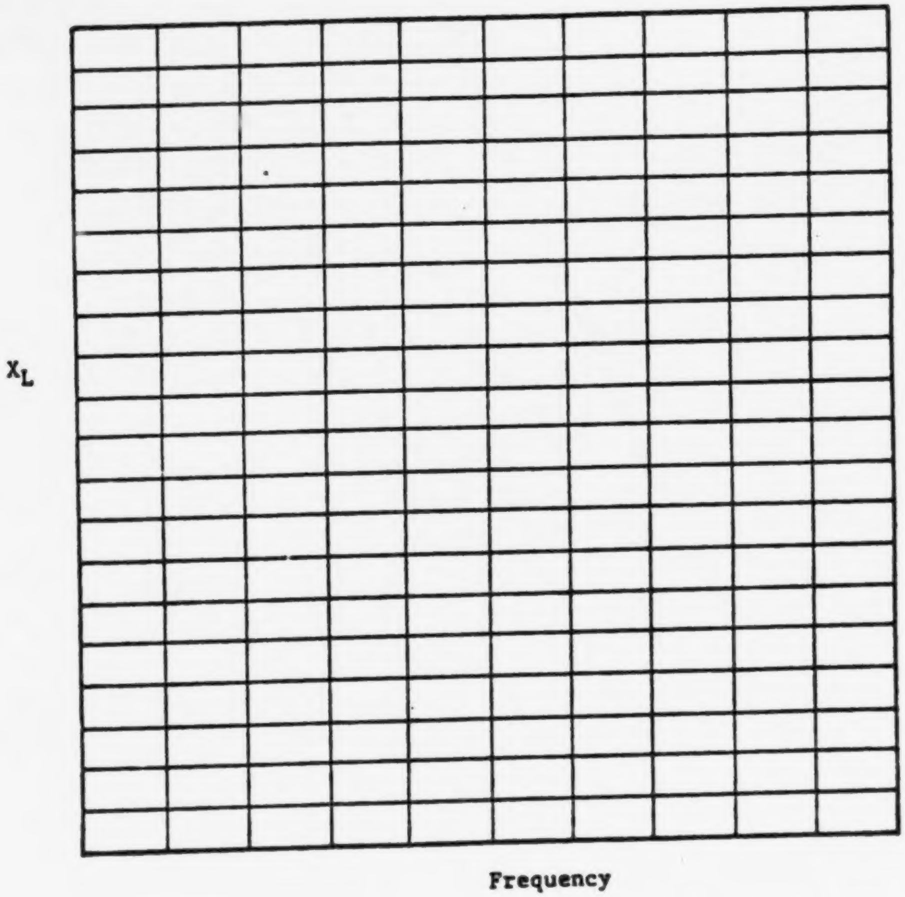
3. Determine the current, I, flowing in the circuit by dividing the resistor, V_R, by the value of R that you are using. (Ohm's Law)

4. Determine the inductive reactance, X_L, by dividing the generator voltage by the current, I.

5. Plot the relationship of X_L to frequency on a graph.

6. The purpose of the experiment is to show you that X_L increases with an increase in frequency. Does your graph show this?

#3



EXPERIMENT

Experiment # 4

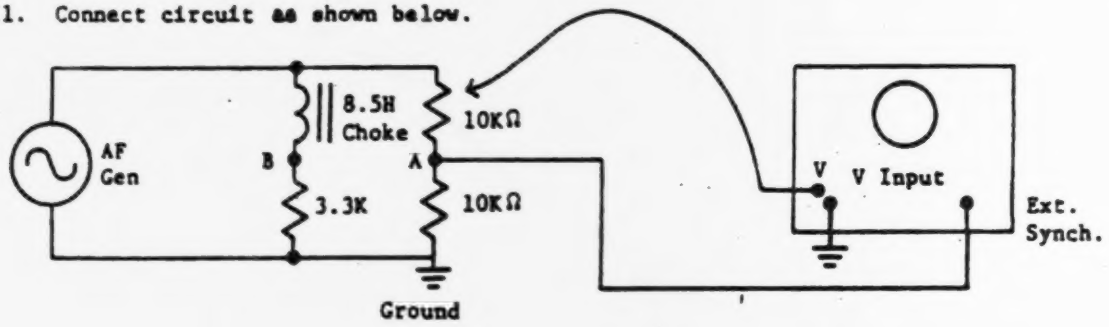
INDUCTIVE PHASE SHIFT

MATERIALS AND EQUIPMENT:

Audio generator
Oscilloscope
Choke 8.5 H
(1) 3.3 K Ω resistor
(2) 10 K Ω resistors

PROCEDURE:

1. Connect circuit as shown below.



2. Adjust AF generator to 200 Hz sine wave max. output voltage. (30 V p-p)
3. Connect common ground of oscilloscope to circuit marked ground.
4. Connect lead from ext. synch. of the scope to point A. Set selector switch to ext. synch.
5. Connect the vertical input of the oscilloscope to point A and adjust oscilloscope for two cycles of a sine wave. The wave form should be about 10 V pk-pk. This is a purely resistive cirucit. Align the peak of one wave on the center line of the screen.
6. Now move the vertical lead of the oscilloscope to point B but do not adjust the scope. Observe that the peak is no longer on the center line and has moved a little less than 90 degrees.
7. Why did the sine wave shift?

Experiment #4 continued.

8. Should the sine wave have shifted more than 90 degrees?

9. This experiment proves that an inductive element will cause a phase shift in voltage.

TRANSFORMERS AND CHOKES

Lab Sheet #14

OBJECTIVES

To learn how to test and measure transformers and chokes
To learn how to measure the inductance of a choke
To learn how to measure and plot circuit impedance

PART A: TRANSFORMERS

INTRODUCTION

Transformers find many uses in electronics. There are power transformers, audio frequency transformers, radio frequency transformers, and special purpose transformers. In PART A you will be testing and experimenting with a POWER TRANSFORMER. This transformer is typical of the type found in the power supplies of many electronic equipments. It has a primary winding and one secondary winding which is center tapped. It converts 110 vac from the "wall power outlet" to a lower voltage. With no load on the secondary, you will observe approximately 14vac. The secondary winding is designed to carry 3 amperes and, at that current, the internal resistance will drop the voltage down to 12.6 vac. The secondary winding has a center tap which can be used for two outputs of 6.3 volts at 3 amperes each.

In these Projects, you will be checking to insure that the transformer windings are not open or shorted to each other or to the iron core. You will then apply 110vac and check out the voltage and frequency. These techniques can be used for nearly all types of transformers.

CAUTION: NEVER ATTEMPT TO MEASURE THE 110 VOLTS AC ON THE TRANSFORMER PRIMARY WINDING, THE AC POWER CORD, OR THE BENCH POWER OUTLET RECEPTACLE.

MATERIALS REQUIRED:

Power transformer(110v to 12.6v)	DMM
Oscilloscope with 1X and 10X probe	VTVM OR VOM

PROJECT 1: Checking a Transformer for OPENS and SHORTS

INTRODUCTION

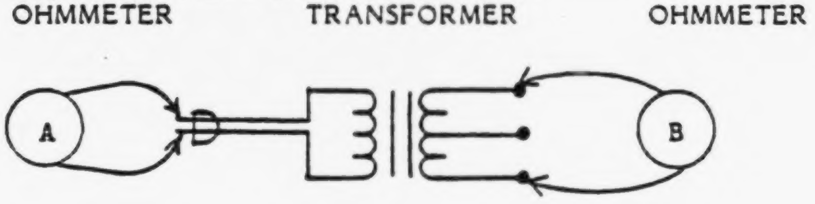
Transformers are a common component in electronic equipment. As a technician, you will need to know how to check them for proper operation, possible damage, and understand their function. In this Project you will learn to check this transformer for "open" or "shorted" windings and proper operation.

INSTRUCTIONS

1. With the transformer unplugged from the 110 vac, use the ohmmeter to check the continuity of the primary winding. That is, measure the resistance from one pin on the AC PLUG to the other pin. This tests for continuity of the cord and the primary winding. Move the cord around to insure that it is not open anywhere, especially near the plug end.

Record primary winding resistance:___________ohms

2. With the transformer unplugged, measure the resistance of the secondary winding. It may be less than 1 ohm. Record below.



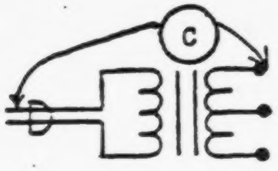
A:________ohms(primary) B:______ohms(secondary)

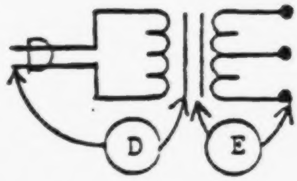
Is the primary winding open? YES/NO

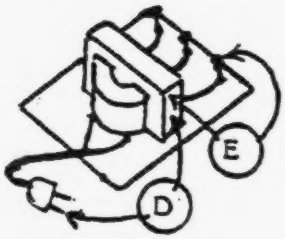
Is the secondary winding open? YES/NO

3. WITH THE TRANSFORMER UNPLUGGED, use the ohmmeter to check for a short between the primary and secondary, then from each winding to the core. Record below.

C:______ohms(primary to secondary)







D:_____ohms(primary to core) E:______ohms(secondary to core)

4. If you measured these approximate resistances, go to STEP 5 below:
   - Primary winding resistance: 20 ohms. YES/NO
   - Secondary winding resistance: 1 ohm. YES/NO
   - Either winding to core: Infinite ohms. YES/NO

5. a. Is the primary or secondary open? YES/NO

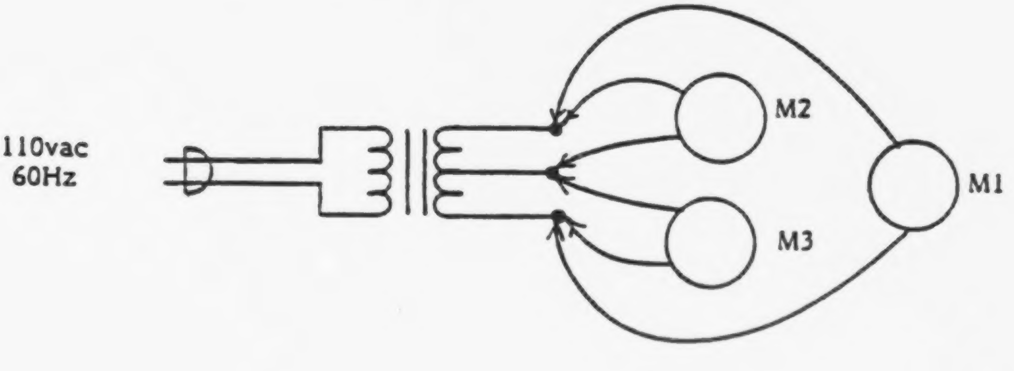
   b. Are the windings shorted to each other? YES/NO

   c. Is either winding shorted to the core? YES/NO

PROJECT 2: Measuring AC Voltage out of the Transformer Secondary Winding, Using an AC Voltmeter

CAUTION: DO NOT MEASURE THE PRIMARY WINDING VOLTAGE!

1. Set the DMM to measure "AC volts".
2. Plug the transformer AC cord into the lab bench 110 vac power outlet.
3. Using the DMM, measure the AC volts out of the transformer secondary winding as shown above. Record below in meters.



4. Did you get approximately 14 volts across the full winding (M1)?

YES/NO

Did you get half the full voltage from center tap. to each end (M2 and M3)?

YES/NO

What is the turns ratio of this transformer? __________

Is it a step-up or step-down transformer? ____________

5. Set the VTVM to measure AC volts, and make the same voltage measurement on the transformer secondary. Record.

M1____vac M2____vac M3____vac

Is it the same as read by the DMM?

YES/NO

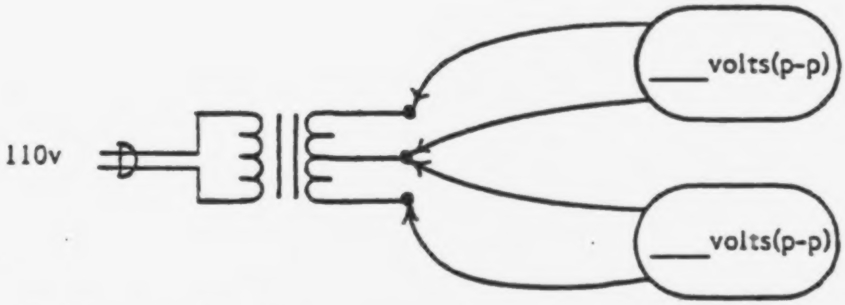
PROJECT 3: Measuring Transformer Output Voltage with the Oscilloscope

1. Use the scope to measure the transformer secondary voltage output. Record in the space on the schematic below.

HINTS FOR BEST SCOPE OPERATION:

VERTICAL AMPLIFIER CONTROLS
DISPLAY-------------IN
AC/DC OUT---------IN
VOLTS/DIV-----------5
POSITION-------Center sweep on CRT.

HORIZONTAL AMPLIFIER CONTROLS
SECONDS/DIV-------5ms
AUTO TRIG-----------IN
SOURCE(LEFT)-------IN
LEVEL---------Adjust for best display.



2. Measure the voltage across the full secondary and record:________vac(p-p).

NOTE: You may find that the full secondary peak-to-peak voltage is so large that you cannot see it all on the scope graticule. If this is so, do this:

a. Check out a "Ten-to-one probe" for the scope.

b. Set the probe switch to "10X". (This will cut the voltage by 10X.)

c. Replace your scope coax lead with this probe.

d. Measure the transformer secondary voltage with this 10X probe.

e. Multiply your scope voltage measurement by 10.

3. Convert your peak-to-peak voltage measurements from STEP 2 to rms voltage, and compare with your DMM readings.

Are they the same? YES/NO

4. Set the VTVM to read AC volts. Measure the transformer secondary voltage, using the VTVM peak-to-peak scale near the bottom of the meter face.

Do you get the same reading as in STEPS 1 and 2? YES/NO

PROJECT 4: Measuring Frequency of the Transformer Secondary AC Voltage

1. Disconnect the scope from the transformer secondary.

> Disconnecting the scope lead before going to the next step will prevent you from accidently shorting out the transformer. This could happen if the two scope lead common grounds were connected to different points in the circuit. Since this transformer is capable of producing 3 amperes, considerable heat and possible damage could occur.

2. Connect the Frequency Counter directly to the transformer secondary with a coax lead. Measure the frequency of the output voltage. Record.

Frequency:__________Hertz

3. Remove the Frequency Counter from the transformer and connect the scope to the secondary as done before.

4. Using the scope, measure the PERIOD of one cycle and calculate the frequency.

Period:__________seconds.

$$\text{FREQUENCY} = \frac{1}{\text{time(seconds)}}$$

Is your frequency in STEP 4 the same as in STEP 2? YES/NO

PROJECT 5: Calculating Transformer Internal Resistance

INTRODUCTION

In this Project you will only do calculations. You WILL NOT be using the transformer or test equipment.

> DO NOT CONNECT UP ANY EQUIPMENT TO VERIFY THIS PROJECT. YOU HAVE NO COMPONENTS WHICH WILL WITHSTAND THE HEAVY CURRENTS INVOLVED.

1. This transformer is designed to provide 12.6 volts at 3 amperes. What value resistor would be required to pass this current? _____ohms _____watts

2. Assume you had the load in STEP 1 connected. The voltage is 12.6vac and 3 amps are flowing through the load. Calculate how much the voltage changed from the unloaded condition to the loaded condition, and determine the INTERNAL RESISTANCE(Rint) of the secondary winding. (NOTE: You measured the unloaded voltage in PROJECT 2. Use that value.)

$$\text{Rint} = \frac{\text{(Vno load) - (Vloaded)}}{\text{(Iload)}} = \underline{\qquad}\text{ohms}$$

3. When the load is connected and 3 amps are flowing, how much current is flowing in the primary?

$$\frac{Vpri}{Vsec} = \frac{Isec}{Ipri}$$

I_{Pri}:________mA.

4. When the transformer secondary is loaded and 3 amps are flowing, how much power is going into the primary winding? (Assume the transformer is 100% efficient.)

$$Power_{Secondary} = I_{sec} \times E_{sec}$$

Power in secondary:________ = Power in primary:________.

SUMMARY:

You should have learned these things:

1. Transformer windings can be checked for opens using an ohmmeter.

2. Shorted turns in the windings cannot always be identified with an ohmmeter since low voltage-high current windings normally have a very low resistance (1 ohm or less).

3. An ohmmeter can be used to check for (1) shorts between the primary and secondary windings, and (2) between each of the windings and the core. The transformer should never be plugged in when using an ohmmeter on it.

4. Transformers can step-down voltage and at the same time increase the current available. However, the power out of the secondary can never be more than the power into the primary.

5. Transformers have internal resistance which affects the output voltage and current. This resistance is made up of two components: DC ohms (as measured by the ohmmeter) and AC ohms (called inductive reactance). As current increases through a winding, the voltage drops because of these two resistive components.

6. AC voltage from a transformer can be measured with an oscilloscope or an AC voltmeter. When using the scope it is easiest to measure peak-to-peak, and then convert to rms. Most AC voltmeters indicate rms voltage, and some (like the VTVM) indicate both rms and peak-to-peak.

7. Transformers do not change the frequency of an AC voltage.

8. Hazardous voltages exist (1) at the lab bench AC power outlet, and (2) on the plugged-in transformer primary winding.

9. You must be careful when connecting two pieces of test equipment with common grounds to an operating transformer. The ground leads must always be connected to the same electrical point to avoid shorting out the transformer output. This would cause high current to flow; overheating it, and causing possible damage to it or the test leads and test equipment.

10. There is a relationship between the turns ratio of a transformer and the voltage and current output.

PROJECT 6: Self Evaluation Quiz

INSTRUCTIONS

Select the best answer and cross out all incorrect answers. Check your responses with the correct answers at the end of this quiz.

1. A transformer (can) (cannot) step-up frequency.
2. A transformer (can) (cannot) step-up voltage.
3. A transformer (can) (cannot) step-up current.
4. A transformer (can) (cannot) step-up power.
5. An increase of current in the load, on the secondary winding, causes (more) (less) current to flow in the primary winding.
6. The transformer you used had (more) (less) turns on the primary than on the secondary.

7 A transformer with a higher voltage in the secondary than in the primary will have(more) (less) current in the secondary than the primary.

8. Current is limited in a transformer winding due to (the core) (the wire only) (a resistor) (both DC and AC ohms).
9. When a transformer is plugged in, an ohmmeter (should) (should not) be used to check resistance of the secondary.
10. Transformers (can) (cannot) be used to step-up DC.
11. A voltage step-up transformer will have more turns of wire on the (primary) (secondary) winding.
12. All frequencies (are) (are not) coupled through a transformer equally well.
13. DC resistance and impedance (are) (are not) equal in all transformers.
14. A transformer (can) (cannot) block DC but pass AC.
15. The current and voltage out of the secondary will be limited by (turns ratio only) (turns ratio and internal resistance).

Answers to PROJECT 6: Self Evaluation

1. cannot
2. can
3. can
4. cannot
5. more
6. more
7. less
8. both DC and AC ohms.
9. should not
10. cannot
11. secondary
12. are not
13. are not
14. can
15. turns ratio and internal resistance.

PART B: INDUCTANCE(L) AND INDUCTIVE REACTANCE(X_L)

INTRODUCTION

Inductors are coils made in many forms to do a variety of tasks. Several types are on the inductor board. A coil opposes any change in current. Therefore, AC current is opposed in a coil. This opposition is called INDUCTIVE REACTANCE and is measured in ohms. DC current is not affected by inductive reactance.

A coil is not a perfect inductor because it contains both inductive reactance and resistance. No energy is lost in the inductive reactance, but some energy is lost in the resistance of the wire and is dissipated as heat. The combination of reactance and resistance in an AC circuit is known as IMPEDANCE.

In the following Projects you will observe how to check a coil with an ohmmeter, how to find the inductance if it is not marked on the coil, and how a coil reacts to various frequencies.

MATERIALS

Inductor board
2 Scope leads
Power Transformer (110v to 12.6v)
Resistors: 4.7k and 10k
DMM
Oscilloscope

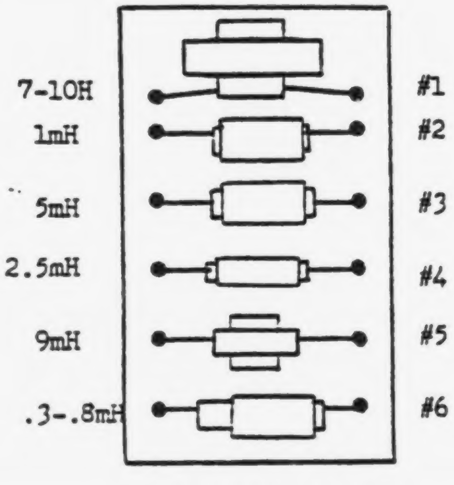
PROJECT 1: Checking an Inductor for OPENS and SHORTS

INDUCTOR BOARD

1. Locate FILTER CHOKE(#1) on the inductor board. It is a coil of wire wrapped around a laminated iron core. This choke is used as a filter to "smooth out" DC in a power supply. It has large enough wire to carry the current required with little loss due to heat. The large number of turns and the iron core give this choke a high amount of inductance.

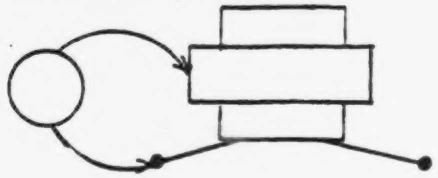
2. Using the ohmmeter, determine if the filter choke is open. Record the resistance of the coil: ______ohms.

NOTE: This is the DC resistance of the choke. Because this choke has a large number of turns, the resistance of this long wire is approximately 500 ohms.

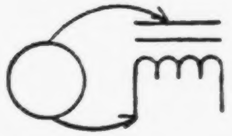


INDUCTOR BOARD

3. Using the ohmmeter, determine if the filter choke coil is shorted to the iron core. Record:_________ohms. (NOTE: Check the resistance from the metal frame and core to the winding terminals. If it is not shorted, you should get infinite ohms.)



OR



4. If you read less than lkohms through the coil, and infinite ohms between the coil and iron core, it is probably in good working order. Continue with the next Project.

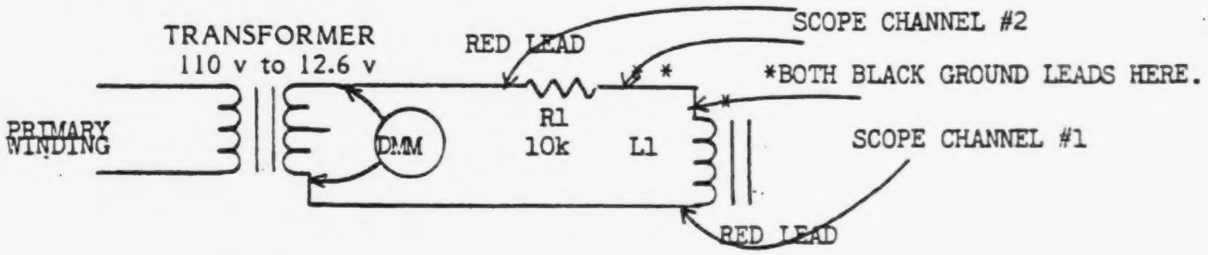
PROJECT 2: Finding the Unknown Inductance of a Filter Choke

1. Connect the circuit below using filter choke #1 (7 to 10 Henrys).

NOTES: R1 is in the circuit as an additional load to limit current flow. Also, R1 will allow you to calculate current flow by measuring the voltage drop across it.

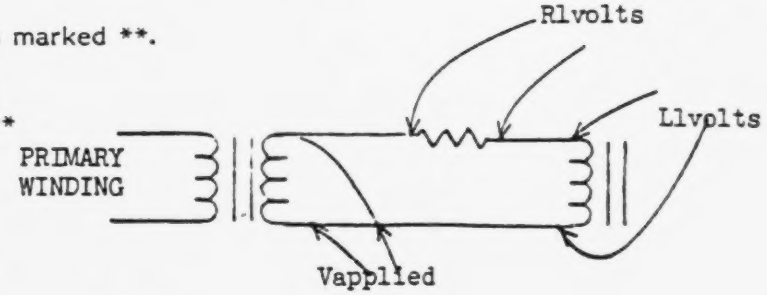
You are using both the DMM and scope here for practice. Do not use the VTVM in place of the DMM because some VTVM's have a common ground. The DMM has a "floating ground" which will not cause problems with the scope common grounds. Make sure both scope common ground leads are connected to the same point.

You will be using two traces on the scope to observe two different signals simultaneously. For best display, push the "CHOP" button IN on the scope Horizontal Amplifier.


TRANSFORMER
110 v to 12.6 v
RED LEAD
SCOPE CHANNEL #2
*
*BOTH BLACK GROUND LEADS HERE.
*
PRIMARY WINDING
DMM
R1
10k
L1
SCOPE CHANNEL #1
RED LEAD

2. With the transformer plugged in to the 110vac power receptacle, and using both the DMM AC voltmeter and the scope as shown, measure the voltages where indicated below. Record.

NOTE: Calculate voltages marked **.
Measure the others.
SECONDARY _____v(rms)
SECONDARY _____v(p-p)**
R1 _____v(p-p)
R1 _____v(rms)**
L1 _____v(p-p)
L1 _____v(rms)**


Rlvolts
Llvolts
PRIMARY
WINDING
Vapplied

3. Calculate the total current (Itotal) in the circuit.

$$\text{Itotal} = \frac{\text{R1volts(rms)}}{\text{R1}} = \underline{\hspace{2cm}}\,\text{mA(rms)}$$

4. Calculate the total IMPEDANCE of the circuit (Zckt).

NOTE: Vapplied(rms) IS THE SECONDARY VOLTAGE, NOT 110vac ON THE PRIMARY

$$\text{Zckt} = \frac{\text{Vapplied(rms)}}{\text{Itotal}} = \underline{\hspace{1.5cm}}\,\text{ohms}$$

NOTE: It is important to recognize that this IMPEDANCE(Zckt) is the total opposition to current flow in the circuit. It is the algebraic sum of the total resistance (R1 and winding wire resistance), plus the inductive reactance of the inductor.

5. Calculate INDUCTIVE REACTANCE (X_L).

$$X_L = \frac{E_{L1}\,\text{(rms)}}{\text{Itotal}} = \underline{\hspace{2cm}}\,\text{ohms}$$

NOTE: Since there is some resistance in the inductor wire, this is not pure inductive reactance that you calculated here. However, since R1 is 10 times the value of the inductor internal resistance, we will disregard the internal resistance of the inductor and accept our calculated value as pure X_L.

6. Now that you have the inductive reactance (X_L) of the choke, calculate the INDUCTANCE (L) of the choke using this formula:

$$L = \frac{X_L}{(2\pi F)} = \underline{\hspace{1.5cm}}\,\text{Henrys}$$

where F is a frequency of 60 Hertz.

SUMMARY

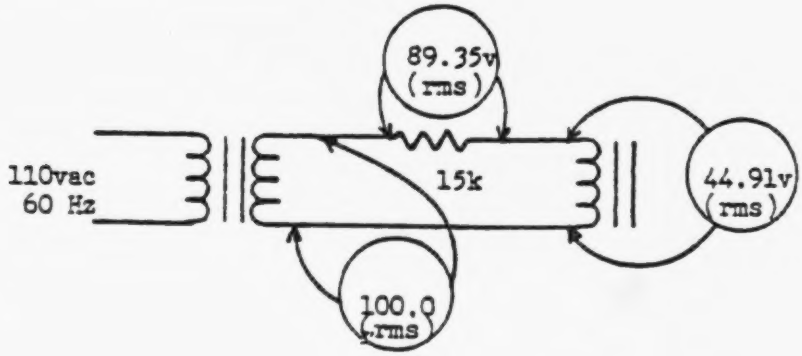
You should have learned to check a filter choke, using an ohmmeter, to insure that the coil is not open or shorted to the core.

Using a simple AC circuit and the basic formulas, you should have learned to approximate the inductance of an unmarked filter choke.

NOTE: In this Project, you were using a frequency of 60 Hertz to check the filter choke since it had a high value of inductance. Soon you will be working with small value inductors and using higher frequencies to check them.

PROJECT 3: Self Evaluation and Practice in Finding Inductance and Impedance

1. DO NOT CONNECT THIS CIRCUIT. Just do the calculations, using the procedures that you used in PROJECT 2. Find the data indicated below by using the values shown below in the "meters".



Choke inductance:______Henrys

Circuit impedance(Z):_____ohms

Inductive reactance(X_L):______ohms

Total current:______mA

PROJECT 4: Observing How an Inductor Affects AC Current Differently than DC Current

INTRODUCTION

In this Project you will apply the same DC voltage that was applied with the AC transformer. For example, if your transformer output was 13.6 volts rms AC, you will apply 13.6 volts DC. You will see how the current is different even though the voltage is the same. The difference is due to the inductive reactance (X_L) which affects only AC current.

INSTRUCTIONS

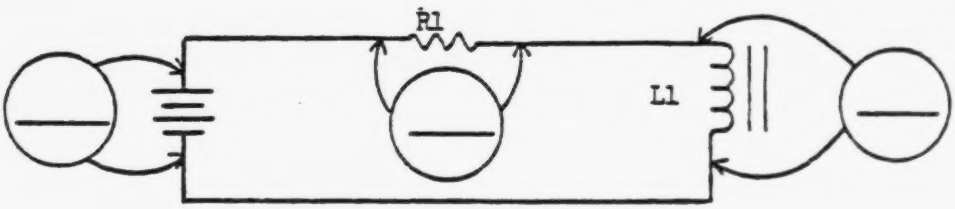
1. Using the same circuit and data gathered in the preceding PROJECT 2, calculate the following:

How much DC current would flow in the choke and resistor series circuit, if the transformer were replaced by a DC power supply? _______mA.

HINTS: The DC voltage should be the same as the AC rms value. Since only DC resistance is in the circuit, then the formula for current is simply this:

$$I = \frac{\text{Eapplied}}{(\text{R1} + \text{Rchoke})} = \_\_\_\_\_\_\_ \text{mA}$$

2. You will now verify your calculations. Remove the transformer from the circuit. Connect the DC power supply and set the power supply DC voltage to the same voltage (rms) value supplied by the transformer in the previous Projects. Record DC voltage measurements in the meters below.



3. Measure the voltage across R1 and calculate current flow. Record.

Itotal(DC)__________mA

4. Is this close to what you calculated in STEP 1? YES/NO

SUMMARY

You should have observed that the filter choke opposed AC current more than DC current. It should be obvious that the DC circuit performed very predictably in accordance with Ohm's Law. However, the AC circuit had another factor affecting current flow: inductive reactance(X_L). Inductive reactance is an additional factor affecting current flow in AC circuits with inductors. Inductive reactance can be calculated this way:

$$X_L = 2\pi F L$$

The TOTAL OPPOSITION to current flow in an AC circuit is known as IMPEDANCE(Z). Impedance of the circuit (Zckt) can be calculated in the following two ways, plus several other ways with different data.

$$\text{Zckt} = \frac{\text{Eapplied(rms)}}{\text{Itotal(rms)}} \quad \text{or} \quad \text{Zckt} = \sqrt{(\text{Rtotal})^2 + X^2_L}$$

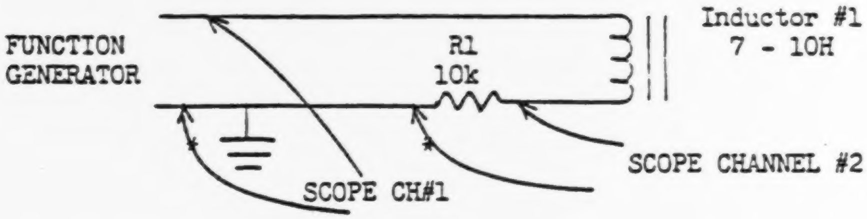
PROJECT 5: Observing the Effect of Frequency on Inductive Reactance

INTRODUCTION

Instead of using the transformer as a source of AC power you will now use the function generator. This will allow you to observe different frequencies affecting the inductive reactance of the inductor. Later you will use a different value of inductance and repeat the measurements.

INSTRUCTIONS

1. Using the same filter choke (#1), connect the circuit below.
NOTE: The scope and the function generator have a common ground through the coax cables. Therefore, both grounds (*black leads) must be connected to the same electrical point in the circuit.



2. Set the Function Generator output for 2 volts (peak-to-peak) at 100 Hertz. Use channel #1 of the scope to measure this voltage. Also use channel #1 to trigger the scope.

3. Using channel #2 of the scope, measure the voltage(p-p) across R1. Record in TABLE 1 below the "R1 volts" (p-p) and (rms).

4. Set the function generator to each of the other frequencies in TABLE 1. Measure the voltage across R1 for each frequency and record the "R1 volts" (p-p) and (rms). Insure that the Vin is the same for each frequency by readjusting the Function Generator AMPLITUDE control if necessary.
NOTE: Make more, or fewer, frequency measurements to get a smooth curve of points in order to see the trend clearly.

$I = \frac{E_{MEAS}}{R}$

USE
$Z = E_A / I_{MEAS.}$

TABLE 1

FREQUENCY	Vin	R1 volts (p-p)	(rms)	Itotal (rms)		IMPEDANCE (ohms)		X_L
		CALC	MEAS.	CALC.	MEAS.	CALC.	MEAS.	
100	2							
500	2							
1000	2							
2500	2							
5000	2							
10000	2							

5. Calculate Itotal in the circuit for each frequency, and then record in Table 1 under "I total".
Note: Use rms value of R1 voltage to find Itotal.

$$\text{Itotal} = \frac{\text{R1volts(rms)}}{\text{R1}} = \_\_\_\_\_\_\text{mA(rms)}$$

6. Calculate Impedance for the circuit(Zckt) and record under "IMPEDANCE".

$$Zckt = \frac{Vin(rms)}{Itotal(rms)} = \_\_\_\_\_\_ \text{ ohms}$$

7. On the attached graph paper(ATTACHMENT #1), plot the IMPEDANCE versus FREQUENCY curve for this circuit.

Does your graph show that impedance increases as frequency increases? YES/NO

PROJECT 6: Practice in Measuring and Plotting Circuit Impedance

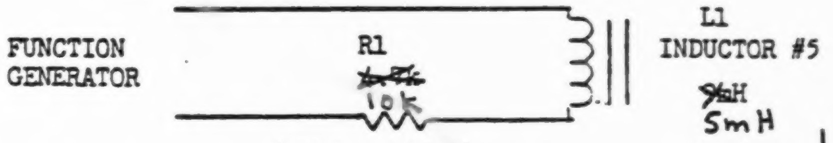
INTRODUCTION

In this Project you will repeat the previous Project procedures using a different choke and different frequencies. You will not have detailed instructions. See if you can do the Project using your understanding of the equipment and theories involved. When working with amplifier circuits, this procedure for plotting frequency response curves will be used often next semester. Learn it well.

INSTRUCTIONS

1. Assume that you have the circuit below in a particular piece of electronic equipment. The purpose of the circuit is to pass all frequencies below a certain range and attenuate frequencies above this range. The circuit is called a LOW PASS FILTER. To determine the characteristics of the circuit, you must test the circuit and plot the impedance versus frequency curve.

2. Connect the circuit below, and make the necessary measurements to plot the impedance versus frequency curve. Plot the impedance curve on ATTACHMENT #2. NOTE: Since this is a small value choke, only higher frequencies are affected. Use the frequencies listed below (more or fewer) to test the circuit enough to get a smooth curve.



FREQUENCY	Vin (p-p)	R1volts (p-p)	R1volts (rms)	Itotal (rms)	IMPEDANCE(Zckt) (ohms)		X_L
		CALC	MEAS		CALC.	MEAS.	
250KHz							
500KHz							
750KHz							
1 MHz							

NOTE: Be prepared to hand in your graph to the Instructor if he asks for it.

SUMMARY

You should understand these important things about inductors:

A coil of wire exhibits special electrical properties, especially when it is wrapped around an iron core.

We call these coils "inductors" because they have this special property which we call "INDUCTANCE".

Inductance is measured in units called "Henrys". The symbol used for inductance is "L".

Each inductor has a specific amount of inductance because of the way the inductor is constructed.

The number of turns in the winding, shape of the winding, core material, and other physical factors all determine the amount of inductance in an inductor.

The amount of inductance in an inductor is fixed by its construction. (However, when current becomes excessive, the inductance can change due to magnetic field saturation in the iron core.)

Inductance is a property which only affects AC current.

AC current is opposed by the inductance in an inductor. This opposition to AC current flow is called INDUCTIVE REACTANCE.

The symbol for inductive reactance is "X_L".

Inductive reactance(X_L) is measured in Ohms. Sometimes X_L is referred to as "AC Ohms".

Inductive reactance(X_L) is affected by the inductance(L) of an inductor, and the frequency of the AC current applied. It can be calculated this way:

$$X_L = 2\pi F\ L$$

AC current decreases in an inductor if frequency is increased.

AC current is decreased in a circuit if another inductor with higher inductance(L) is installed.

DC current is not affected by the inductance(L) in a circuit. Since the frequency is zero, there is no inductive reactance(X_L) to oppose the DC current.

The only opposition to DC current in an inductor is the resistance of the wire.

Chokes are a type of inductor used to oppose AC current and to pass DC current.

PROJECT 7: Self Evaluation Quiz: Inductors

Cross out the incorrect words to make the statement correct.

1. Coils are (always round) (inductors) (resistors).

2. A filter choke, tuning coil, and radio frequency choke are all (transformers) (resistors) (inductors).

3. Inductors oppose (AC) (DC) current flow.

4. Inductive reactance is measured in (Henrys) (ohms) (feet) (meters).

5. To DC current, an inductor resembles a/an (resistor) (open).

6. The opposition to AC current flow in an inductor is called (inductive reactance) (resistance).

7. A choke has more opposition to AC current than to DC current due to the (inductive reactance) (resistance) (internal resistance).

8. An iron core choke (like #1 on the Inductor Board) is usually used in electronic equipment such as the (oscillator) (amplifier) (power supply filter).

9. A choke like #2 on the Inductor Board is often used in (high frequency) (low frequency) (power supply) circuits.

10. A choke possibly could be shorted from the winding to the (AC plug) (iron core) (Inductor Board).

11. The inductive reactance (X_L) in an inductor increases when the (windings decrease) (voltage increases) (frequency increases) (core decreases).

12. The AC current in an inductor will be low when the (inductance) (frequency) (voltage) (resistance) is low.

13. When the frequency is high, current in an inductor will be (low) (high).

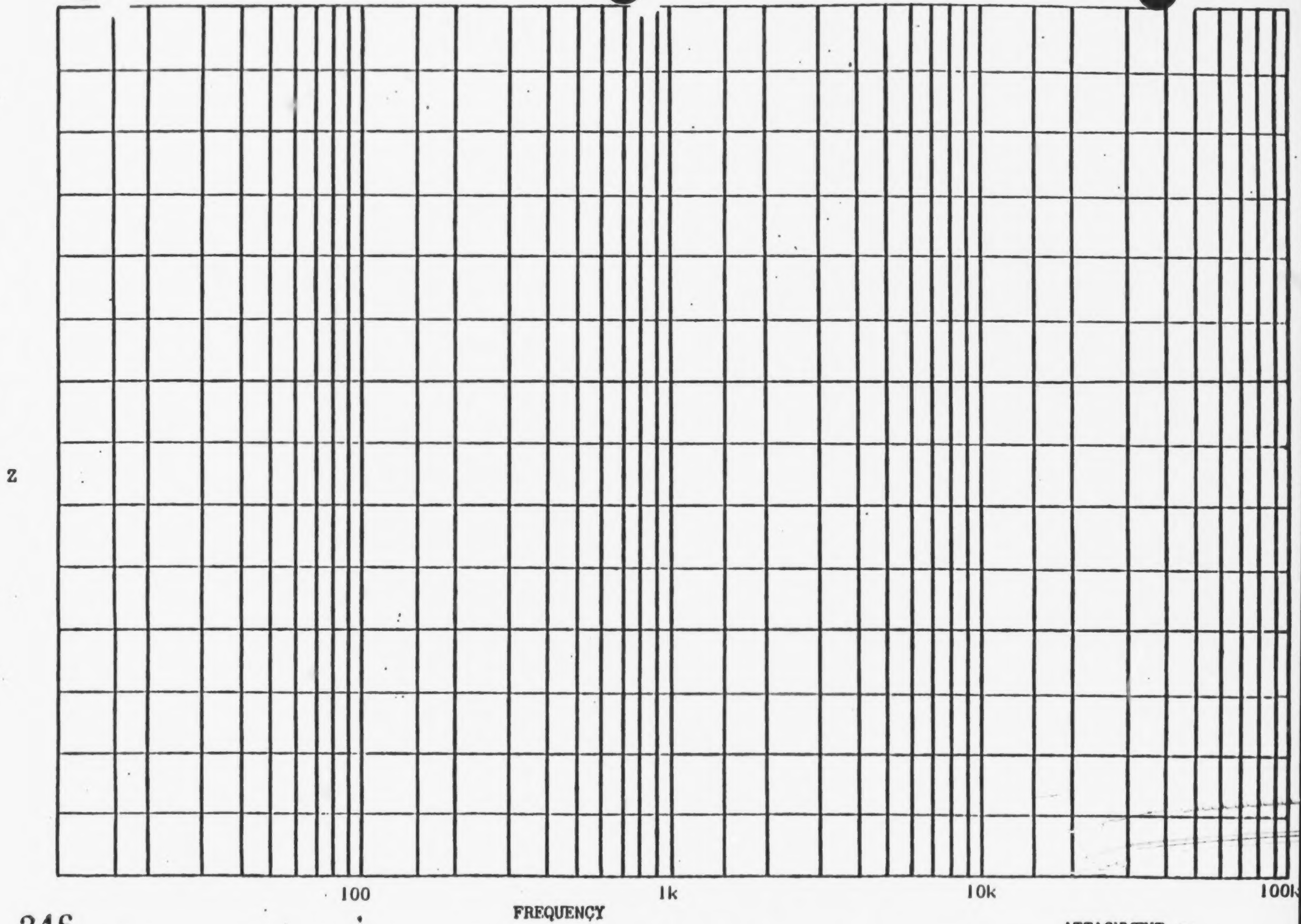
14. A choke with a heavy iron core and many turns of large wire probably has high (inductive reactance) (inductance) (resistance).

15. A choke with a small iron core and small wire probably has high (inductive reactance) (inductance) (resistance).

Answers to PROJECT 7: Self Evaluation Quiz: Inductors

1. inductors
2. inductors
3. AC
4. ohms
5. resistor
6. inductive reactance
7. inductive reactance
8. power supply filter
9. high frequency
10. iron core
11. frequency increases
12. voltage
13. low
14. inductance
15. resistance

Your score: ____________ How did you do? Great OK *&$$#@!!



ATTACHMENT #1

INDUCTIVE PHASE SHIFT

Lab Sheet #15

OBJECTIVES

To observe inductive phase shift
To learn to solve phase shift problems using trigonometric functions
To learn how a loudspeaker operates
To learn how an inductance microphone operates

INTRODUCTION

When a source of A.C. is connected to an inductor, the current increase is opposed each half cycle. This means that, during each half cycle while the voltage is changing toward the peak + or - value, the current is lagging behind the voltage applied. The current does reach its maximum value, but only after the voltage has reached its maximum value and continued on to the next part of the cycle. The current lags the voltage by 90 degrees if there is only inductance and no resistance in the circuit. Since this is impossible to achieve in actual circuits, we will find a phase shift less than 90 degrees across a circuit with only a coil and some internal resistance of the wire in the coil.

The circuit you will use has a coil and a series resistor to limit current, and allow voltage measurements for current calculations. This added resistor will cause the phase shift to be even less across the circuit. However, across only the coil the phase shift will be closer to 90 degrees.

This phase shift phenomena is used to advantage in some equipment and, in other equipment, it is a problem to be overcome by special means. Your goal in these next Projects is to understand the nature of this phase shift. As a technician working on sophisticated electronic equipment you must be aware that each wire has some small amount of inductance. Bending the wire increases the inductance. A loop in the same wire greatly increases the inductance. Put several loops together and we have an inductor or coil with a significant amount of inductance to higher frequencies. This inductance causes the voltage and current to get out of phase with each other, as well as change the impedance of the circuit. For example, if you merely bend the wrong wire in a television set tuner you can cause it to be inoperative.

In the following Projects, you will be using some new formulas and trigonometric functions as you experiment with phase shift in the circuits. If you need to review the use of your calculator on trigonometry problems, do that before you tackle these Projects. Be sure that you have done your reading assignment before doing these Projects. It is suggested that you read it again after doing the Projects, too.

MATERIALS

Inductor Board
Oscilloscope
Loudspeaker
Function Generator
Resistors: 2k fixed value and 200k potentiometer

PROJECT 1: Measuring Phase Shift in a Resistor-Inductor Circuit

INTRODUCTION

In a series resistor-inductor circuit, like in Figure 1, the current is the same throughout the series circuit. The voltage drop across the resistor(R1volts) is in phase with the current(Itotal) through the resistor. This is true because $E_R = I \times R$.

Meanwhile, at the coil, the voltage across the inductor(L1volts) leads the current through the inductor by close to 90 degrees. This happens because the inductor delays the current changes until after the applied voltage to the series circuit reaches its peak value.

In Figure 2 is a vector diagram showing the 90 degree leading voltage across the inductor(E_L) and the voltage across the resistor, which represents current. (NOTE: The voltage across the resistor(E_R) is used to determine what the current in the inductor is doing. We can do this because it is a series circuit where current is the same throughout and $E_R = I \times R$). Also shown is the resultant vector sum of the two. The resultant is the total phase shift between the applied voltage(Eapplied) and the circuit current(I_T), due to the inductor and all of the resistance in the resistor and the coil wire.

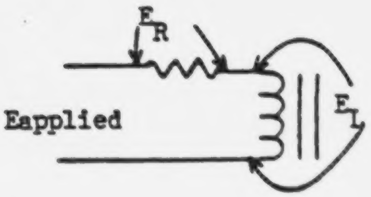
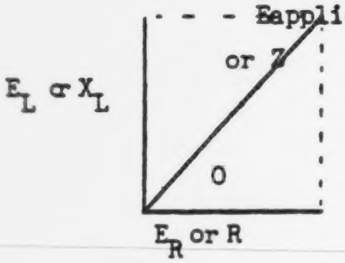


Figure 1



$$Eapp = \sqrt{E_R^2 + E_L^2}$$

$$Z = \sqrt{R^2 + X_L^2}$$

Figure 2

Go slowly on these concepts and sort them out in your own way as necessary. Do not just skip what you don't understand, "fill in the blocks" in these Projects, and kid yourself that you have learned something important. Keep in mind that you are developing your knowledge and skills here on which you are going to base your career in electronics.

Don't forget what the contractor for the Leaning Tower of Pisa in Italy said: "We'll save a little time and money on the foundation and nobody will ever know the difference."

One of the first things to recognize in these Projects is this: The total phase shift in the circuit is measured as an angle, called "theta", and expressed with the symbol "θ". The angle is measured in degrees and is a function of circuit resistance and inductive reactance. The circuit phase shift (that is, the angle between applied voltage and circuit current) can be calculated using trigonometric functions with the resistance and inductive reactance in this manner:

$$\frac{X_L}{R1} = \text{TAN } \theta$$

NOTE: "TAN θ" is the tangent of the phase shift angle θ. From this you can find the angle in degrees by pushing the "ARC TAN" button on your calculator. It is very simple once you understand it.

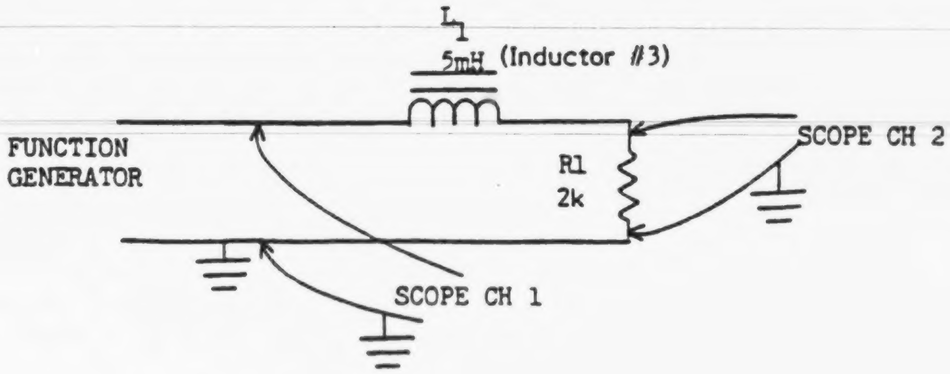
Other trigonometric relationships for such a circuit are these:

$$\frac{X_L}{Z} = \text{SIN } \theta \qquad \frac{R}{Z} = \text{COS } \theta$$

In these next Projects you will practice using the above powerful mathematical tools. As a technician you will seldom need to measure phase shift. However, it is always occurring in any circuit where there is reactance. Sometimes we use it to our advantage, and other times it becomes a serious problem of which you should be aware. Phase shift problems are often very hard to identify and correct. For example, music reproduced by a cheap radio or amplifier does not sound like "live" music, partly due to different amounts of phase shift for each of the different frequencies. As you do the following Projects, pay particular attention to how the phase shift occurs and what is causing it to do what it does.

INSTRUCTIONS

1. Connect the circuit below.



2. With the Function Generator connected to the circuit, set its AMPLITUDE for an applied voltage of 4 volts p-p. Use this signal to trigger your scope (that is, set the scope TRIGGER SOURCE for channel #1).

3. Study what you have connected now. Do you recognize that this circuit is a form of a voltage divider? Therefore, when the inductive reactance (X_L) is equal to R1 resistance, the voltage drops across L1 and R1 will be equal. BUT EACH VOLTAGE WILL BE GREATER THAN ONE-HALF THE APPLIED VOLTAGE. Actually, each voltage drop will be 70.7% of the applied voltage when X_L is equal to R1. Since X_L varies with frequency, X_L will be equal to R1 only at ONE frequency.

In STEP 4 you will first calculate 70.7% of the applied voltage. That is when R1volts is equal to L1volts. Then in STEP 5 you must find the frequency at which R1volts is equal to L1volts.

And if that isn't enough to worry about, there is still the common ground problem. You can't measure both L1 and R1 voltages simultaneously with the test equipment. You must swap places with the resistor and inductor in the circuit to measure the voltage across each, one at a time. You will be on your way to success with this Project when you (1) keep the circuit a series circuit and (2) keep the common grounds connected together. OK, give it a try.

4. Calculate the value of R1volts and L1volts when X_L is equal to R1. (NOTE: You can use either all rms or all p-p voltage values, just be consistent.)

Eapplied X .707 = ________volts

NOTE: This above formula comes from this trigonometry formula, NOT the rms formula:

Eapplied X SIN θ = L1volts

And since we are setting R1volts equal to L1volts, the angle will be 45 degrees. SIN 45 = .707. Don't confuse this with the formula for rms because we are using the value ".707".

5. Adjust the FREQUENCY of the function generator until you find the one frequency in which you get the voltage calculated in STEP 4 dropped across the resistor. Insure that the applied voltage(Eapplied) from the function generator is still 4 volts. Record.

R1volts______________

8. Using one of the new tools you now have, find the impedance of this circuit:

$$\frac{R1}{Z} = \cos\theta \qquad \text{therefore } Z = \frac{R1}{\cos\theta} = \_\_\_\_\_\_ \text{ohms}$$

9. Compare your answer in STEP 8 with this way of finding Z.

$$Z = \frac{E_{applied}}{I_{total}} = \_\_\_\_\_\_\_\_ \text{ohms}$$

$$\text{where} \quad I_{total} = \frac{R1\text{volts}}{R1} = \_\_\_\_ \text{mA}$$

SUMMARY

In a series R-L circuit, the current is the same in both the resistor and the inductor.

The voltage and current at the resistor are in phase.

The voltage leads the current at the inductor.

When R1 and L1 are equal in ohmic value, the applied voltage leads the circuit current by 45 degrees. This happens because the inductor delays the current through the circuit.

As frequency increased, the phase angle increased. This occurred because the inductor delayed the current even more at higher frequencies, meaning that the X_L increased.

One way to analyze R-L circuits is to use the "voltage divider" technique.

Another way to analyze R-L circuits is to use trigonometric functions.

There are several trigonometric formulas you now have to analyze R-L circuits.

You should recognize that you now have many ways to find mathematical solutions to A.C. circuit problems.

PROJECT 2: Practice Using Trigonometric Functions to Solve A.C. Circuit Problems

INTRODUCTION

Here are some of the mathematical tools you can use with R-L circuits:

$$\tan\theta = \frac{X_L}{R} \qquad \sin\theta = \frac{\text{L1volts}}{\text{Eapplied}}$$

$$\tan\theta = \frac{\text{L1volts}}{\text{R1volts}} \qquad \text{L1volts} = \sin\theta \times \text{Eapplied}$$

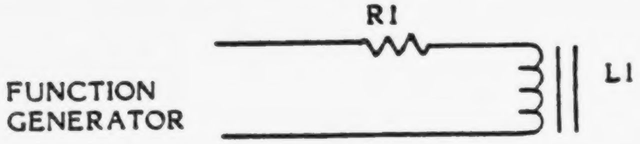
$$\text{R1volts} = \cos\theta \times \text{Eapplied}$$

$$\text{Eapplied} = \frac{\text{L1volts}}{\sin\theta} \qquad Z = \frac{X_L}{\sin\theta}$$

$$\text{Eapplied} = \sqrt{E^2_{R1} + E^2_{L1}}$$

INSTRUCTIONS

1. Connect the series R-L circuit below. Using the mathematical tools in the PROJECT 2 INTRODUCTION and all that you know about series R-L circuits, find the data indicated in TABLE 2. Swap L1 and R1 around as necessary to prevent common ground problems when making measurements.



See TABLE 2 for values.

NOTE: With the new trigonometry formulas in the INTRODUCTION, you can use ANY frequency since you do not need equal voltages across L1 and R1. However, use a frequency that gives you a phase shift between 30 and 60 degrees for greatest accuracy. To approximate the frequency, do this:

1. Monitor the applied voltage(Eapplied) on channel 1 and the voltage across the inductor(E_L) on channel 2.
2. Adjust the FREQUENCY of the function generator until E_L is approximately one half of Eapplied.
3. Use this Frequency to determine the remaining data.

TABLE 2:

INDUCTOR #	R1 ohms	FREQUENCY KHz	L1volts p-p	R1volts p-p	TAN θ	θ degrees	INDUCTANCE Henrys
3	2k						
4	2k						

SUMMARY

You should be able to find the inductance of an unknown inductor by using both the "voltage divider" technique and the trigonometric formulas. If you can't, go back and practice until you can do so easily and rapidly. You may be tested on this and must do it again when you study capacitors.

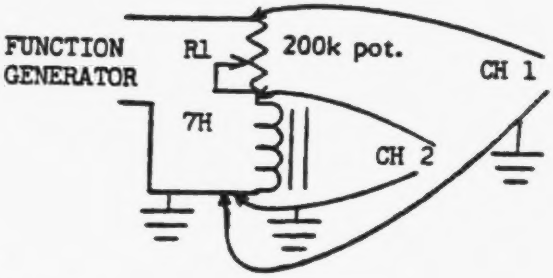
PROJECT 3: Observing Phase Shift with the Oscilloscope

INTRODUCTION

With the circuit below, you will be able to see the phase shift in an R-L circuit. Be sure to keep the common grounds connected together.

INSTRUCTIONS

1. Connect the circuit shown.



2. Set the Frequency for 1kHz.
3. Set the scope for dual trace operation.
4. Vary the potentiometer and observe the phase shift.
5. Can you adjust the potentiometer for 45 degrees phase shift? YES/NO
6. Remove the potentiometer and measure the resistance with the DMM.

Is it approximately the value of the inductor X_L? YES/NO

PROJECT 4: Self Evaluation Quiz: Phase Shift

Cross out the incorrect words to make the statements true.
HINT: Use the vector diagram to help answer some of these questions.

1. Inductors in a series R-L circuit cause current to (lead) (lag) the voltage applied.

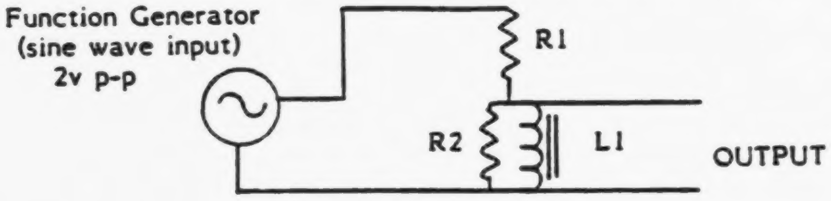
2. In a series R-L circuit the inductance is cut in half. The phase angle will (increase) (decrease) (stay the same).

3. In a series R-L circuit the applied voltage is doubled. The phase angle will (stay the same) (increase) (decrease).

4. In a series R-L circuit only the resistance is increased. The phase angle will (remain the same) (increase) (decrease).

5. In a series R-L circuit the frequency is increased. The phase angle will (remain the same) (increase) (decrease).

NOTE: Use the below schematic to answer questions 6 through 16.



6. If the input frequency were increased, the output signal amplitude would (stay the same) (increase) (decrease).

7. If the input frequency were decreased, the output signal phase shift would (stay the same) (increase) (decrease).

8. If the input frequency were increased, the circuit impedance would (stay the same) (increase) (decrease).

9. If R2 were to open, the output signal amplitude would (stay the same) (increase) (decrease).

10. If R1 resistance were doubled, the output signal amplitude would (stay the same) (increase) (decrease).

11. If R1 resistance were reduced to one-quarter, the output signal frequency would (stay the same) (increase) (decrease).

12. If L1 inductance were doubled, the output signal amplitude would (stay the same) (increase) (decrease).

13. If L1 inductance were doubled, the current through R1 would (stay the same) (increase) (decrease).

14. If L1 inductance were doubled, the current through R2 would (stay the same) (increase) (decrease).

15. If L1 inductance were decreased, the output signal phase shift would (stay the same) (increase) (decrease).

16. If L1 inductance were doubled, and the input signal frequency were doubled, then the output signal amplitude would (stay the same) (increase) (decrease).

Answers to PROJECT 4: Self Evaluation: Phase Shift

1. lag. 2. decrease. 3. stay the same. 4. decrease. 5. increase.

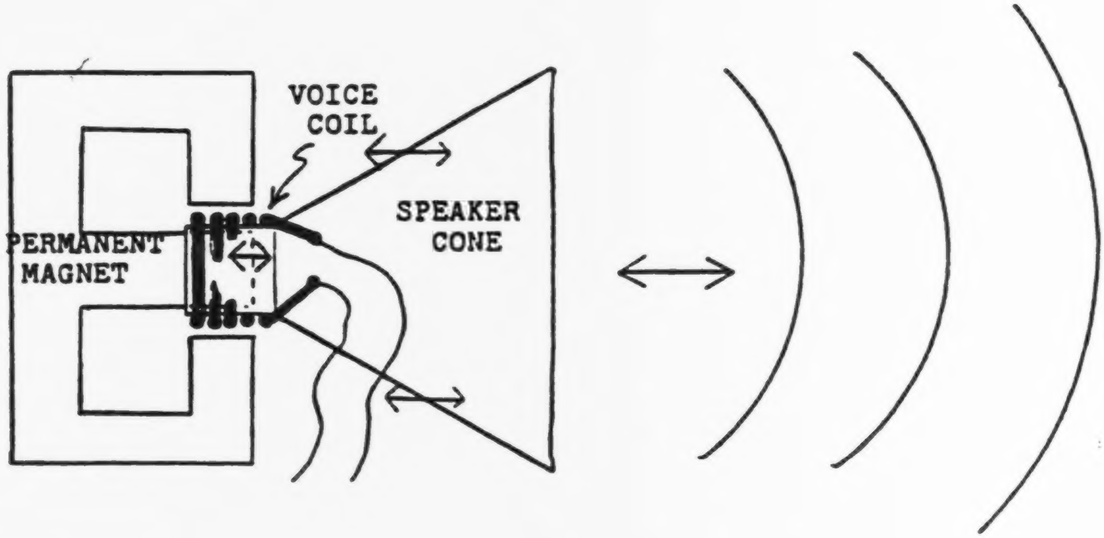
6. increase. 7. decrease. 8. increase. 9. increase. 10. decrease.

11. stay the same. 12. inc. 13. dec. 14. inc. 15. dec. 16. inc.

PROJECT 5: Experimenting with an Inductive Type of Device: THE LOUDSPEAKER

INTRODUCTION

Most electromagnetic loudspeakers are constructed as shown below. Voice and music frequency currents through the voice coil cause a varying magnetic field. The voice coil and the speaker cone move back and forth as the electromagnetic fields alternately attract and repel the permanent magnet. The cone vibrations radiate as sound into the surrounding air.



Even though the basic principle used to move the cone in accordance with the incoming frequency is simple, there are other variables. One of these is the relationship between cone size and the frequencies most efficiently radiated. Large diameter speakers (called woofers) are used for low frequencies. Smaller diameter speakers (called mid-range and tweeters) are used to radiate higher frequencies.

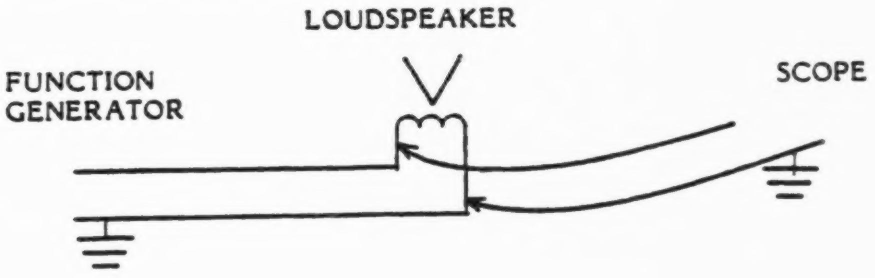
We have seen that movement of a coil can be caused by a varying current flow through a coil in a magnetic field. Also, you should know that moving a coil in a magnetic field produces current flow. This second principle is used in inductance types of microphones. In this Project, first you will observe the speaker used to reproduce sound from a varying voltage and current. Next, you will observe the speaker used as a microphone to produce a varying voltage and current.

INSTRUCTIONS

1. Inspect the loudspeaker for physical damage to the delicate cone.

2. Check electrical continuity of the speaker voice coil with an ohmmeter. Record the resistance:________ohms. NOTE: This is the D.C. resistance of the loudspeaker, not the impedance.

3. Connect test equipment as shown below.



4. Turn the function generator "on" and adjust it to 3KHz. Set the AMPLITUDE control on the function generator for a very low volume tone out of the speaker. It should only be loud enough to be heard at your lab bench.

5. Adjust the scope for best display of the signal and measure the amplitude of the signal. Notice that there may be distortion of the sine wave. For your measurements, use what appears to you to be the peaks, and be consistent. Record.

Vin(3KHz)_________mV(p-p)

> This recorded voltage is your reference for all other measurements to follow. DO NOT CHANGE THE AMPLITUDE CONTROL ON THE FUNCTION GENERATOR. YOU WILL CHANGE ONLY THE FREQUENCY CONTROLS FOR THE BELOW MEASUREMENTS.

NOTE: You will now observe the effectiveness of this speaker for reproducing different frequencies listed below. You will use a very inaccurate instrument to do this task: the human ear. Since the ear is much more sensitive to frequency changes than to volume changes, this experiment need not be taken too seriously. What you should observe, however, is that this speaker is a better tweeter than a woofer!

6. Adjust the function generator to each of the frequencies listed and note if you can hear the tone out of the speaker. Do not change the amplitude(Vin) used at 3KHz.

FREQUENCY	AUDIBLE (YES/NO)
100Hz	
500Hz	
1KHz	
2KHz	
3KHz	
4KHz	
5KHz	
6KHz	

NOTE: These are only very rough approximations of loudness and everyone will sense it differently.

What is the highest frequency you can hear at the reference voltage? _______

What is the lowest frequency you can hear at the reference voltage? _______

7. Disconnect the function generator and leave the scope connected to the speaker.

8. Use the speaker as a microphone by speaking into it. Observe the audio frequency voltages on the scope. Can you make a sine wave with your voice?

PROJECT 6: Self Evaluation Quiz: Loudspeakers and Microphones

Select the best response. Check your answer with the correct answers at the end of the quiz.

1. A moving coil inside a magnetic field produces a/an __________ voltage.

a. D.C. b. A.C. c. North d. South

2. A loudspeaker can reproduce__________ frequencies.

a. all b. some c. no d. radio

3. A small loudspeaker reproduces______audio frequencies best.

a. low b. high c. loud d. all

4. In a loudspeaker, the moving electrical part is called the _________.

a. permanent magnet. b. cone.
c. voice coil. d. zorch coil.

5. A loudspeaker operates as a microphone because the sound waves move the ______ to produce an A.C. voltage.

a. permanent magnet b. frame
c. air d. cone and voice coil

6. Your voice does not produce sine waves because of _________.

a. harmonics. b. D.C. voltages. c. bad coils.

7. An ohmmeter on electromagnetic type of loudspeaker measures_______.

   a. impedance. b. inductance. c. inductive reactance. d. resistance.

A microphone operates using principles similar to the________.

   a. generator and alternator. b. resistor and potentiometer.

9. Loudspeakers have low resistance and can handle high current.

   a. True b. False

10. Loudspeakers can be damaged by too much current because________.

   a. the cone is immovable. b. the voice coil is made of fine wire.

Answers to PROJECT 6: Self Evaluation Quiz: Loudspeakers and Microphones

1. b
2. b
3. b
4. c
5. d
6. a
7. d
8. a
9. b
10. b

Your score: __________

How did you do? Had a lot of fun. It was OK. Suffered miserably.

Self Test

1. What distinguishes the primary winding from the secondary winding?

2. How is the connection made between the windings?

3. What is flux leakage?

4. What is the phase relationship between primary current and voltage for an unloaded transformer?

5. Name four primary transformer losses.

   a.

   b.

   c.

   d.

6. What is the relationship of primary power and secondary power?

7. What is the formula for determining voltages across a transformer using the turns ratio?

AMERICAN RIVER COLLEGE
ELECTRONICS DEPARTMENT

10/77/ch

Electronics 75

QUIZ ON RMS AND TRANSFORMERS

DIRECTIONS: Place your student number in the upper right hand corner of a scantron answer sheet. Indicate you choice of the best answer with a dark pencil mark on the answer sheet. Please do not mark on this quiz.

1. 18 volts peak-peak are how many volts RMS?

   a. 18v   b. 9 v   c. 6.3v   d. 5v

2. 120 volts RMS are how many volts peak-peak?

   a. 120 v   b. 240v   c. 300v   d. 340v

3. 80 volts peak-peak are how many volts RMS?

   a. 14.14v   b. 28.28v   c. 40v   d. 80v

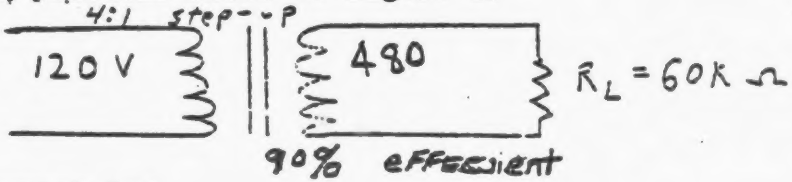
4. 5 volts RMS are how many volts peak-peak?

   a. 7.07v   b. 14.14v   c. 28.28v   d. 1.77v

5. 12 volts peak-peak are how many volts RMS?

   a. 6v   b. 12v   c. 4.24v   d. 42.42v

For the following problems refer to figure I.



6. Secondary current is:

   a. 5 amps   b. 8 amps   c. 2 ma   d. 8 ma

7. The output power is:

   a. 3.84 W   b. 1.92 W   c. 19.2 mw   d. 3.84 mw

8. The input power is:

   a. 1.92 W   b. 3.84 W   c. 4.25 W   d. 5.26 W

9. The output impedance of an amplifier is 4800 ohms. What would be the turns ratio for the output transformer if the speaker has 8 ohms impedance?

a. 600:1 b. 34.7:1 c. 1:24.5 c. 1:7

10. The output impedance of an amplifier is 12k ohms. What would be the turns ratio for a 30 load?

a. 1:400 b. 1:40 c. 1:20 d. 400:1

11. What would be the turns ratio for a 15 ohms load in problem 10?

a. 1:40 b. 1:28.3 c. 40:1 d. 80:1

12. The turns ratio on a transformer is 1:40. A 4 ohms speaker would match what size output impedance?

a. 5 ohms b. 1600 ohms c. 6400 ohms d. 160 ohms

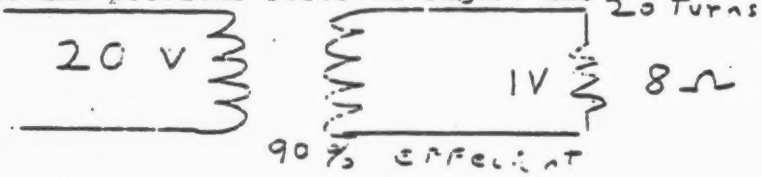
13. If a step-up transformer has an impedance of 64:1600 and has 100 turns of wire in the primary, how many turns does it have in the secondary?

a. 500 b. 2500 c. 250 d. 1250

14. Find the turns ratio of a transformer that would match the impedance of a power transistor that has 512 ohms impedance to a speaker with 8 ohms impedance.

a. 800:1 b. 1:8 c. 64:1 d. 1:54

For the following problems refer to figure II.



15. The volts per turn of the primary is:

a. .05v b. 1v c. 20v d. 5v

16. The impedance ratio is:

a. 1:20 b. 1:400 c. 1:1 d. 20:1

17. The number of turns in the primary is:

a. 20 b. 40 c. 200 d. 400

18. The impedance of the primary is:

a. 3200 ohms b. 400 ohms c. 160 ohms d. 8 ohms

19. The power of the secondary is:

a. 50W b. 5W c. 2.5W d. .125W

20. The current in the primary is:

a. 125 ma b. 2.5 a c. 6.25 ma d. 6.95 ma

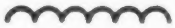
mm

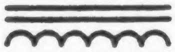
Self Test

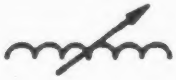
Directions Do the following problems.

1. Write a definition for the term "inductance."

2. Match the symbols for various inductor types to the names.

_____1 Iron core inductor a. 

_____2 Variable inductor b. 

_____3 Air core inductor c. 

3. How is voltage induced from one coil into another?

4. List three factors that influence the amount of inductance in a coil.

   a.

   b.

   c.

5. The unit of inductance is the ____________________.

6. The letter symbol for inductance is ____________________.

Self Test continued.

7. Convert the following units:

a. 100 mh = H

b. 8.5 H = mh

c. 250 μh = H

d. .0025 H = μh

8. What is the inductance of a coil that induces 100 V when the current changes at the rate of 25 ma in 5 μsec?

L = ______________

9. Calculate the inductance L for an air core coil with 20 turns, area 3.14 cm^2, length 25 cm.

L = ______________

10. How much self induced voltage can be developed across a 2H coil produced by a current change of 4 A/sec.

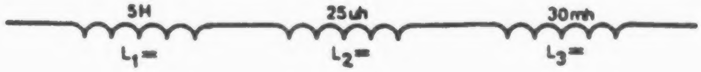
e_L = ______________

11. Two 300 mh coils L_1 and L_2 have a coefficient of coupling k equal to 0.4, calculate M .

M = ______________

12. Calculate the following values.

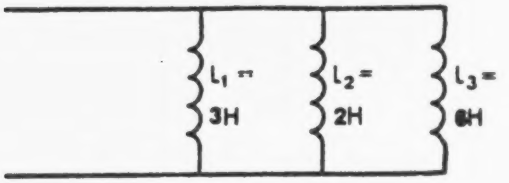
a.



L_T ______________

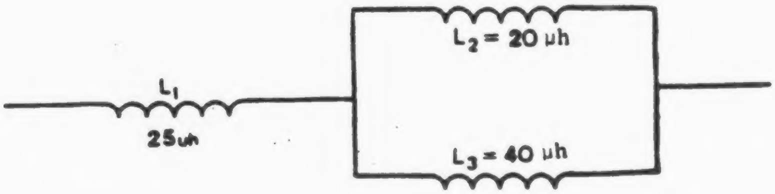
Self Test continued.

b.


L_1 =
3H
L_2 =
2H
L_3 =
6H

L_T ____________

c.

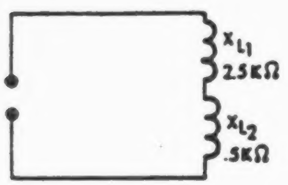

L_1
25μh
L_2 = 20 μh
L_3 = 40 μh

L_T ____________

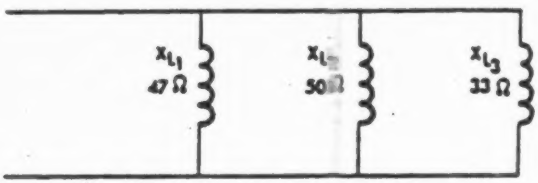
Self Test continued.

9. Given two circuits below calculate X_{LT} for each.

a)



b)



X_{LT} ________________

X_{LT} ________________

10. An inductor is increased from 340 mh to 1.7 H. How much will X_L change?

11. What is the phase relationship between current and voltage in a purely inductive circuit?

12. Given an inductive circuit, the frequency is doubled. How do the following change?

(a) X_L

(b) current

(c) phase

Qviz 166

INDUCTIVE REACTANCE NAME ____________________

POST-EVALUATION A SCORE /

Circle all of the inductive reactance formulas:

. 1. $L = e_L/di/dt$ 2. $f = \frac{X_L}{2\pi L}$ 3. $L_T = L_1 + L_2$

4. $X_C = \frac{1}{2\pi f C}$ 5. $e_L = L \, {}^{di}/_{dt}$ 6. $L = \mu \frac{N^2 A}{e}$

7. $L = \frac{X_L}{2\pi f}$ 8. $X_L = 2\pi f L$ 9. $L_m = K\sqrt{L_1 L_2}$

II. A. Tell in your own words the difference between inductance and inductive reactance:

B. State the phase relationship between voltage and current in a purely inductive AC circuit:

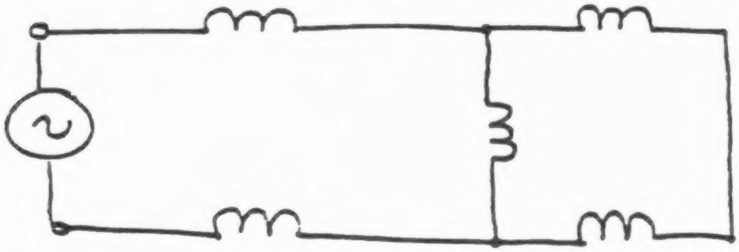
III. A. Determine the reactance of a 56mH coil at a frequency of 810 KHz.

X_L = ____________

B. Ask your instructor for an inductor, for which you are to experimentally determine its reactance at a frequency of 10 KHz.

X_L = ____________

C. Determine the total reactance for this network:

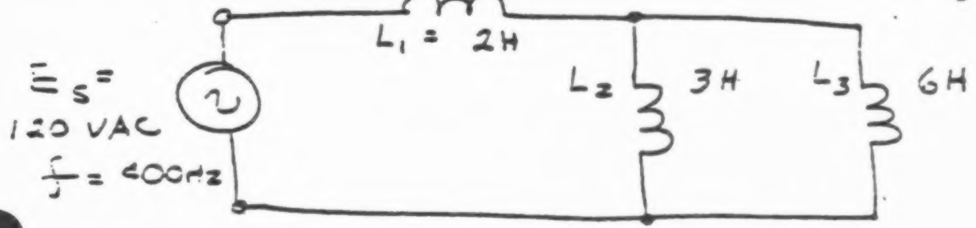


ALL X_L'S = 600Ω

X_{LT} = ____________

IV. Determine the current flowing through L_3.

I_{L_3} = ____________



V. A 32 volt 60 Hz arc welder is to operate at 75 amps maximum. Determine the minimum inductance required to limit current to that value.

L = ____________

Quiz

167

INDUCTIVE REACTANCE   NAME ____________________

POST-EVALUATION E   SCORE /

ircle all the inductive reactance formulas:

I. 1. $L_m = K\sqrt{L_1 L_2}$ 2. $f = \frac{X_L}{2\pi L}$ 3. $L = \frac{X_L}{2\pi f}$

4. $X_C = \frac{1}{2\pi fC}$ 5. $e_L = L\,di/dt$ 6. $X_L = 2\pi fL$

7. $L_T = L_1 + L_2$ 8. $L = \mu \frac{N^2 A}{e}$ 9. $L = e_L/di/dt$

II. A. Tell in your own words the difference between inductance and inductive reactance:

B. State the phase relationship between voltage and current in a purely inductive AC circuit:

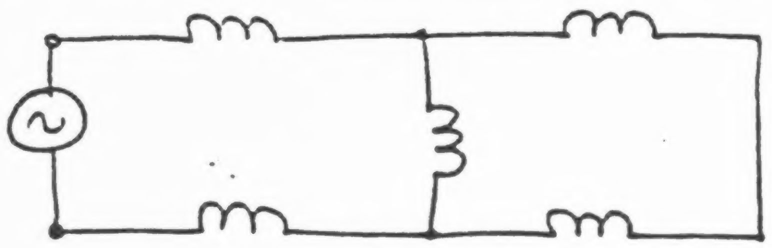
II. A. Determine the reactance of a 47µH coil at a frequency of 54 MHz.

X_L = ____________________

B. Ask your instructor for an inductor, for which you are to experimentally determine its reactance at a frequency of 6.6 KHz.

X_L = ____________________ ohm

C. Determine the total reactance for this network:

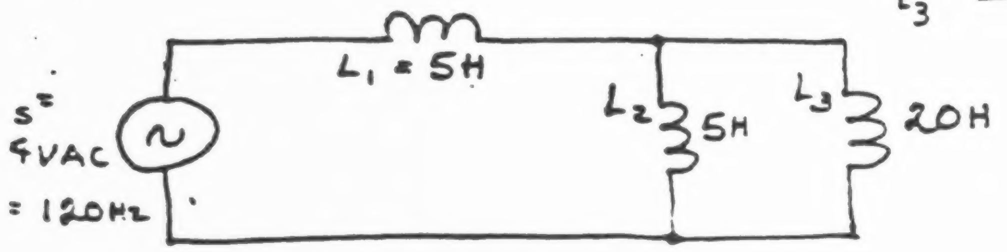


ALL X_L's = 1,200Ω

X_{LT} = ____________________

IV. Determine the current flowing through L_3 in the circuit below.

I_{L_3} = ____________________



V. A 32 volt 60 Hz arc welder is to operate at 90 amps maximum. Determine the minimum inductance required to limit current to that value.

L = ____________________

Quiz 168

INDUCTIVE REACTANCE

NAME ______________________

POST-EVALUATION C

SCORE /

rcle all inductive reactance formulas:

. 1. $L = e_L / di/dt$

2. $e_L = L\, di/dt$

3. $X_L = 2\pi f L$

4. $X_C = \frac{1}{2\pi f C}$

5. $f = \frac{X_L}{2\pi L}$

6. $L = \mu \frac{N^2 A}{e}$

7. $L = \frac{X_L}{2\pi f}$

8. $L_T = L_1 + L_2$

9. $L_m = K\sqrt{L_1 L_2}$

II. A. Tell in your own words the difference between inductance and inductive reactance:

B. State the phase relationship between voltage and current in a purely inductive AC circuit:

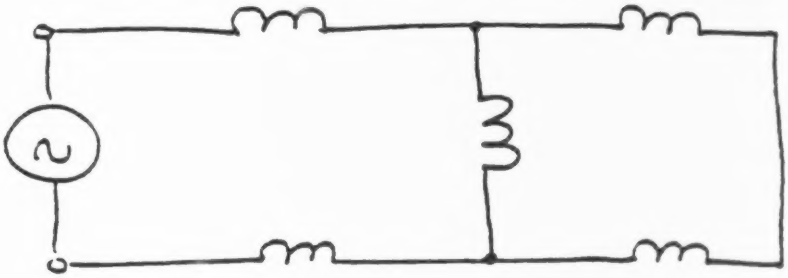
III. A. Determine the reactance of a 330μH coil at a frequency of 21 MHz.

X_L = ______________________

B. Ask your instructor for an inductor, for which you are to experimentally determine its reactance at a frequency of 4 KHz.

X_L = ______________________ ohm

C. Determine the total reactance for this network.

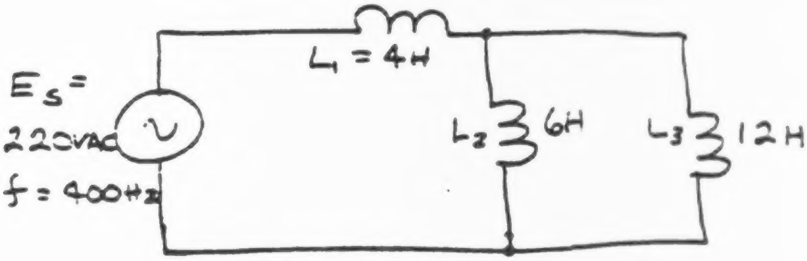


ALL X_L's = 1,800Ω

X_T = ______________________

IV. Determine the current flowing through L_3.

I_{L_3} = ______________________

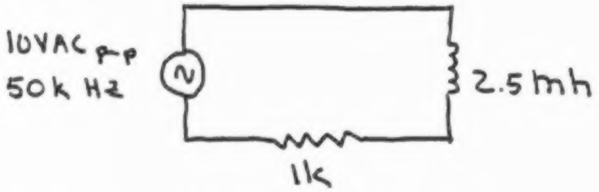


V. A 32 volt 60 Hz arc welder is to operate at 45 amps maximum. Determine the minimum inductance required to limit current to that value.

L = ______________________

NAME ______________________
DATE __________ PER ________

LAB. QUIZ: SERIES RL CIRCUIT



VECTOR DIAGRAM

1. Draw Vector Diagram
2. Do All Calculations (Show all work)
3. Hook up circuit

Formula	Calculations	Calculated Value		Measured Value
________	________	X_L	________	
________	________	∠°	________	
________	________	Z	________	
________	________	Tan∠	________	
________	________	Cos∠	________	
________	________	Sin∠	________	
________	________	V_R	________	________
________	________	V_L	________	________
________	________	I	________	⊛ ________

⊛ TO GET I MEASURED USE THE VOLTAGE MEASURED ON THE RESISTOR AND CALCULATE I.

ELECTRONICS TECHNOLOGY

TEST B INDUCTANCE

NAME________________ DATE________________ SCORE________________

ANSWER THE FOLLOWING QUESTIONS AND PUT THE ANSWERS ON THE LINES IN FRONT OF THE QUESTION NUMBER.

________ 1. Two 10,000 Ohm inductive reactancees in parallel have an equivalent reactance of how many Ohms?

________ 2. The inductance required for a 2KΩ reactance at 20 Mhz is equal to how many Henries?

________ 3. A coil has an inductive reactance of 3,000Ω. If the inductance is doubled, and the frequency is doubled, then the inductive reactance will be how many Ohms?

________ 4. A coil with an in X_L of 5KΩ is connected across a 20 VAC source, what is the I_X?

________ 5. How much is the inductance of a coil with negligible resistance, if the current is 200 mA when connected across 120V 60hz line?

________ 6. A purely inductive circuit, the current will ___________ the

________ voltage by _______°

________ 7. An inductor connected to 120V 60hz, the current flowing through this circuit is equal to 0.8A. What is the inductance?

________ 8. For question 7, show the X_L.

________ 9. A tuning coil in a radio tuner has an inductance of 300uH. What is its reactance at a frequency of 1500 KC?

10. Complete the following:

________ a. What is the letter for inductance?

________ b. What is the unit for inductance?

________ c. 5mH = ______ H

________ d. 8H = ________ mH

________ e. 0.004 H = ______uH

________ f. 1.5Khz = _______hz

11. Write three factors which will INCREASE the inductance of a coil.

____ a.

____ b.

____ c.

F82b

12. Define each of the items(factors) in the Inductive Reactance formula.

____ X_L

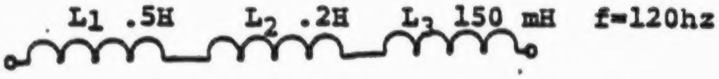
____ 2π

____ f

____ L

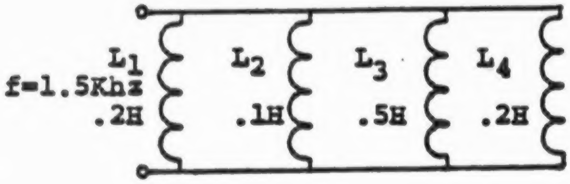
________ 13. Find L_T

________ 14. Find X_L


L1 .5H
L2 .2H
L3 150 mH
f=120hz

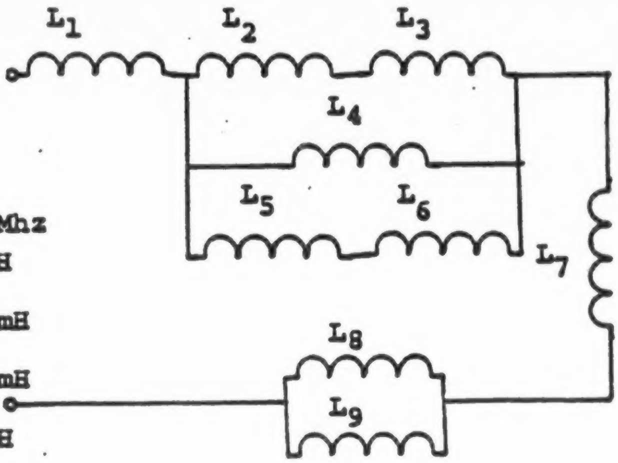
________ 15. Find L_T

________ 16. Find X_L


L1
f=1.5Khz
.2H
L2
.1H
L3
.5H
L4
.2H

________ 17. Find L_T

________ 18. Find X_L


L1
L2
L3
L4
L5
L6
L7
L8
L9

f=107Mhz

L_1=.2mH

L_2=.15mH

L_3=.15mH

L_4=.3mH

L_5=.1mH

L_6=.2mH

L_7=.2mH

L_8=20mH

L_9=.5mH

NAME__________________ DATE______________ GRADE____________

INDUCTANCE

ANSWER THE FOLLOWING QUESTIONS, AND PUT THE ANSWERS ON THE LINES in FRONT OF THE QUESTION NUMBER.

1. In reference to an inductive AC circuit, complete the following statements.

__________ a. As frequency increases X_L ?

__________ b. As frequency decreases E_R ?

__________ c. As frequency decreases E_L ?

__________ d. As frequency increases I_{LINE} ?

__________ e. As inductance increases X_L ?

__________ f. As inductance decreases I_{LINE} ?

__________ 2. Inductive reactance X_L, is the opposition of an ? to the flow of AC current.

3. Briefly define the following factors in the inductive reactance formula.

______________________________ X_L

______________________________ 2π

______________________________ f

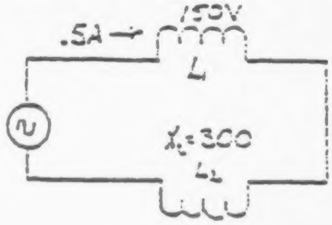
______________________________ L

__________ 4. What is the inductive reactance of an inductor of 17 mH at 2.5 KHz. X_L= ?

__________ 5. How much current will flow through a 0.1 H choke when connected across a 500 Hz, 60 VAC source? I_L= ?

__________ 6. Solve the following: X_{L1}= ?

__________ 7. Find voltage across L_2: E_{L2}= ?



__________ 8. An inductor has a reactance of 37 ohms at 22 KHz, what is its inductance? L= ?

FWL G

9. Write the formula for finding K_L in :

__________ a. series.

__________ b. parallel

__________ 10. At what frequency will a 500 mH inductor cause a reactance of 3.5 K Ohms? f= ?

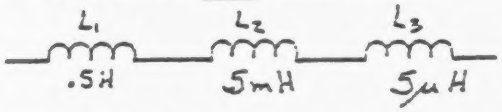
__________ 11. In any inductive circuit the reactance is directly proportional to ? and ?

____

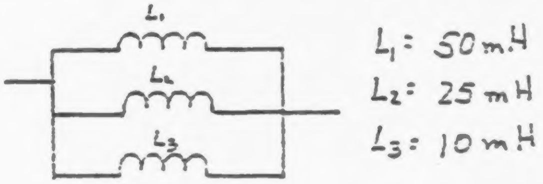
__________ 12. The unit of inductance is called a ?

__________ 13. When electrical energy is transferred from one coil to another, it is called ? induction.

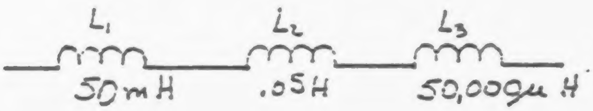
__________ 14. Find L_T.


L1
L2
L3
.5H
5mH
5μH

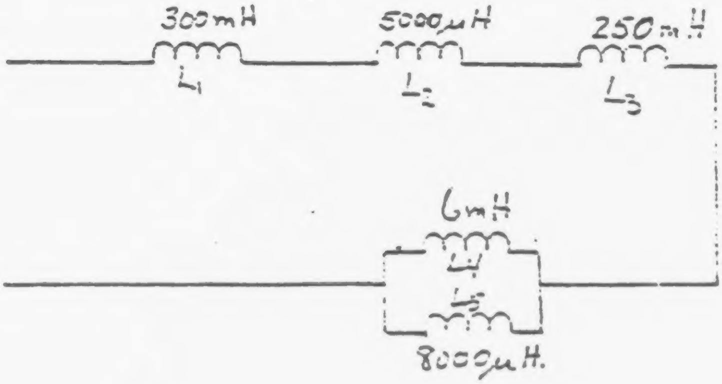
__________ 15. Find L_T.


L1
L2
L3
L1= 50mH
L2= 25mH
L3= 10mH

__________ 16. Find L_T.


L1
L2
L3
50mH
.05H
50,000μH

__________ 17. Find L_T.


300mH
L1
5000μH
L2
250mH
L3
6mH
L4
L5
8000μH.

INDUCTANCE.

Autotransformer: bộ biến thế tự động.

Center-tapped : bộ biến thế có mối nối ở giữa chia đôi output của secondary winding.

coil of wire : cuộn dây,

principle : nguồn chính

Self inductance: tự cảm (sự cảm ứng của cuộn dây).

option : sự chọn lọc, sự chọn lựa

choke = inductor : cuộn cảm điện.

choke off = oppose : chống đối, chống lại.

core : lõi

path : con đường

supporting : nhô cây, nâng đỡ.

concentrating: tập trung.

designation : sự chỉ định.

air core : lõi không khí

iron core lõi sắt.

Counter Electromotive force: (CEMF): Sức phản điện động. ≠ EMF : sức điện động.

Phenomenon : hiện tượng.

Eddy currents: dòng điện nội ứng.

Flux Lines : đường từ thông.

Henry : đơn vị căn bản của Inductance viết tắt : H

Hysteresis : tính từ trễ.

Residual force : từ dư.

remagnetized : từ tính còn lại.

expanding : dãn nở

Collapsing : co lại

Inductive reactance : điện trở AC của inductor. gọi là kháng trở. viết tắt : X_L. đơn vị đo là ohm.

Lamination : sắt cán mỏng.

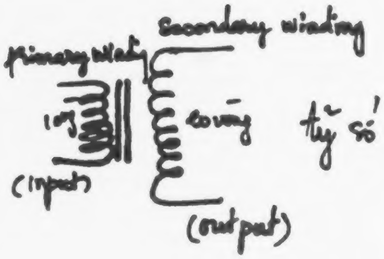
Mutual induction : cảm ứng hỗ tương.

Permeability: tính từ thẩm.

RL time constant: Hằng số thời gian RL

$$T = \frac{L}{R} \Rightarrow L = \frac{V_L}{\frac{di}{dt}}$$

saturation : sự bảo hoà.
Self inductance : tự cảm .
SLUG : lõi kim loại nhỏ có từ tính.
adjacent : vùng tiếp cận. kế cận, lân cận.

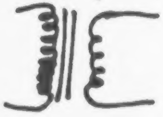


tỷ số vòng : $\frac{N_s}{N_p}$

turns ratio : tỷ số vòng.,
winding : cuộn dây quấn.
Transformer : bộ biến thế gồm 2 cuộn dây quấn. cuộn thứ nhất là primary winding gọi là sơ cấp cuộn thứ nhì là secondary winding gọi là thứ cấp. cuộn sơ cấp (input) cuộn Thứ cấp (output) 2 cuộn dây quấn có tỷ số vòng hoặc bằng nhau hoặc hơn kém nhau. Tỷ số hơn kém gọi là Tỷ số vòng.

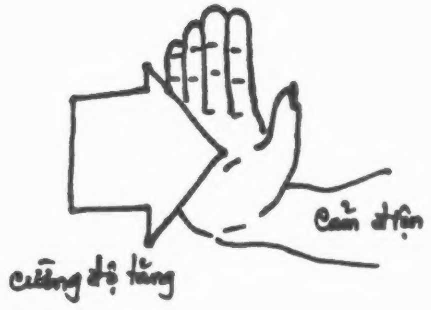
tỷ số : $\frac{20}{10} = 2:1$

tỷ số vòng từ 2 : 1, có nghĩa vòng Sơ cấp 10 vòng vòng thứ cấp 20 vòng. Thì điện thế input vào điện thế output có số vòng lớn gấp đôi nên điện output gấp đôi input. Kết luận transformer step-up.
Còn step down thì Cuộn Sơ cấp nhiều vòng hơn cuộn Thứ cấp

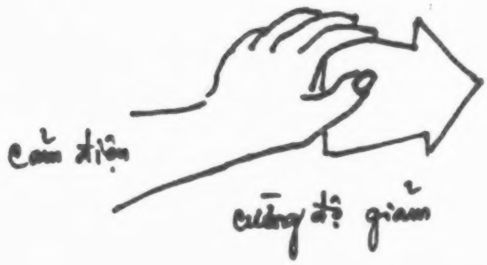


step down.

enamel	:	men, lớp sơn
varnish	:	sơn tráng (vec-ni)


cảm điện
cường độ tăng

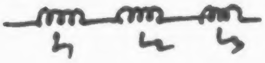
Khi cường độ tăng
cảm điện chống lại
sự thay đổi của
cường độ.


cảm điện
cường độ giảm

Khi cường độ giảm
cảm điện đẩy cường
độ chạy trong mạch.

Công thức tính L tương tự như R trong mạch điện.

Trong series :



$$L_T = L_1 + L_2 + L_3 + \dots L_n .$$

Trong parallel,

$$L_T = \frac{L}{N}$$ khi các inductor tương đương nhau.

$$L_T = \frac{L_1 \times L_2}{L_1 + L_2}$$ khi 2 cái inductor ≠.

$$L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}}$$ khi có từ 3 inductor trở lên.

3. I.

Công Thức tính Cảm kháng X_L
và các công thức suy ra :

$X_L = 2\pi \times f \times L$ $\Rightarrow$ $L = \dfrac{X_L}{2\pi f}$

hay $f = \dfrac{X_L}{2\pi L}$

mà : f = Hertz
2π = 6.28 = (3.14 × 2)
L = Henrys
X_L = ohms

VOLTAGE RATIO : tỷ số điện thế.

$\dfrac{E_s}{E_p} = \dfrac{N_s}{N_p}$. Trong công thức này nếu biết 3 Trị số ta tìm trị số kia.

E_s = điện thế trong cuộn dây thứ cấp (output).
E_p = điện thế trong cuộn dây sơ cấp (input).
N_s = số vòng cuộn dây thứ cấp
N_p = số vòng cuộn dây sơ cấp.

Current Ratio : tỷ số cường độ.

$\dfrac{I_p}{I_s} = \dfrac{N_s}{N_p}$ công thức này được chứng minh từ công suất giữa 2 cuộn dây.

Trên nguyên tắc căn bản công suất của cuộn sơ cấp bằng Công suất cuộn thứ cấp:

$$P_s = P_p \Rightarrow I_s \times E_s = I_p \times E_p \Rightarrow \frac{I_p}{I_s} = \frac{E_s}{E_p}$$

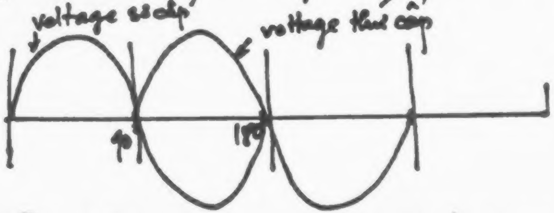
Thay $\frac{E_s}{E_p} = \frac{N_s}{N_p}$ Ta được:

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

Transformer phase relationships:

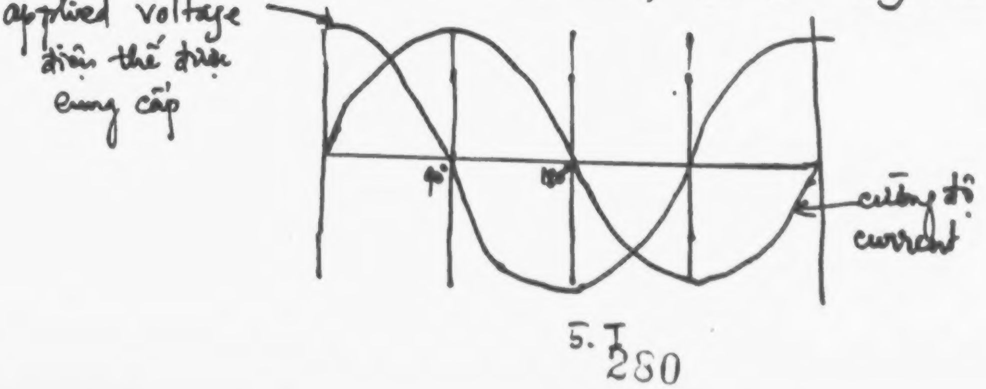
Sự quan hệ góc của bộ biến thế

- giữa voltage của ~~ta~~ 2 cuộn dây trong bộ biến thế một góc 180° out phase. (Voltage cuộn dây thứ cấp đi sau voltage cuộn dây sơ cấp 180°).


voltage sơ cấp
voltage thứ cấp
90°
180°

Sự quan hệ giữa cường độ và điện thế trong mạch hoàn toàn Cảm kháng:

Trong mạch Inductance chống lại sự thay đổi cường độ nên Cường độ đi sau Voltage 90°. Hay voltage đi trước cường độ 90°. (lead : đi trước, dẫn — lag : đi sau).


applied voltage
điện thế được cung cấp
90°
180°
cường độ
current

essential : chính, trọng yếu,
permeable (a) : dễ thấm
permeability(n) : sự thấm, ngấm.
threading : sợi dây
$Q = \frac{X_L}{R}$: Q: điện hưởng xác định giữa tỷ lệ của kháng trở với điện trở trong mạch.
discussion : việc bàn bạc, thảo luận.
versatile : phổ biến.
perform : Thi hành.
array : hàng ngũ. sự xếp hàng
ferrite-core : lõi sắt pha (với một kim loại khác).
select : chọn lọc
reject , từ chối, loại bỏ
XMFR : Transformer (bộ biến thế).
coupling : từng cặp, đôi
stage : giai tầng
encounter : sự (bị) gặp nhau.
instead : thay vì
layout : đồ dùng nhỏ (cầm tay, ở ngoài).
overall : áo giáp, vỏ ngoài.

impedance : tổng trở
discard : chia ra
shock : điện giật, chạm điện.
real : thực, thật
tingler : sự rùng mình (giật)
misplaced : đặt nhầm chỗ.
suffer : cho phép.
defect : tật xấu
previous : đằng trước
matter : vấn đề
internal : bên trong.
widely : rộng lớn.
spark plug : nến lửa phát (bu-gi phát lửa)
Mutual inductance : Cảm ứng hỗ tương ký hiệu L_M.

Công thức tính Cảm ứng hỗ tương

$$L_M = k\sqrt{L_1 x L_2}$$

LM : tính bằng Henry.
K là hệ số của coupling là một hằng số không có đơn vị.
L tính bằng Henry.

Self-induced Voltage : Điện thế tự cảm

Từ công thức : $L = \frac{E_L}{\frac{di}{dt}}$

suy ra

$E_L = L \times \frac{di}{dt}$

mà di : current change
dt : trị số thời gian cường độ thay đổi.

Công thức này anh (chị) ứng dụng vào phần self test phần câu 8,10.

Câu 8.

$$L = \frac{E_L}{\frac{di}{dt}} \begin{cases} E_L = 100^V \\ di = 25\,mA \\ dt = 5\,\mu sec \end{cases}$$

Câu 10 :

$$E_L = L \times \frac{di}{dt} \begin{cases} L = 2H \\ di = 4A \\ dt = 1\,sec \end{cases}$$

Câu 9 tìm L phải áp dụng công thức : $L = 1 \times \frac{N^2 \times A}{l}$

$$\begin{cases} 1 : \text{chiếc suất của không khí (air core)} \\ N = \text{số vòng} = 20 \\ A = \text{area} : 3.14\,cm^2 \\ l = \text{length} = 25\,cm \end{cases}$$

Khi ứng dụng các đơn vị hiện có của bài toán phải đổi ra đơn vị căn bản.

negligible resistance : điện trở không đáng kể.

enter : ghi vào
realize ; thực hiện.
conform ; làm cho xứng hợp
dotted line ; đường gạch gạch
-----

reinforce : làm mạnh thêm
approach : lại gần, tiến gần,

construct : xây dựng, thiết lập.

hysteresis loss ; từ dư bị mất.
Copper losses : Công suất bị tiêu hao do chất đồng dẫn nhiệt.

Super-imposed : không đi với nhau (tạo sự tách biệt).

LIII-412-11

電感 (INDUCTANCE)

技術語彙

autotransformer：自耦变压器.

taped coil：多[接]頭线圈、抽頭线圈.

center tapped：中间抽頭[线]

choke：扼止，抑止，抗流圈.

core：鉄心，芯，核心.

induced：感应.

opposite：相反的

counter electromotive force：反电动势(CEMF)

eddy current：渦流，渦电流

henry：亨利，(电感單位)

hysteresis：滯後(现象)、滯後作用，磁滯.

residual：剩餘的，殘留的

inductance：电感.

collapsing：崩潰，瓦解、摺疊.

indutive reactance：感抗

inductor：电感器，感应线圈

lamination：叠片，分層，(一層層的)薄片.

EMF＝electromotive force 电动势

Lenz's law：楞次定律.

mutual induction：互感应.

permeability：磁導率，滲透性，透过性.

primary winding：原绕线组，一次绕组(輸入线圈.

RL time constant：电阻一电感器時间常數

saturation：飽和，飽和度

secondary winding：次級绕组(輸出线圈)

self inductance：自(电)感.

varying = 変化的, 不同的.

slug = 鉄心, 波導調配柱.

step-down : 降压, 降低, 下降.

step-up = 升压, 升高.

transformer = 变电器 (T)

turns ratio : 匝數比, 线匝比

winding : 绕, 匝.

revolution = 圈, (繞一)環

enamel : 搪瓷, 釉.

varnish : 漆.

henry value : 亨利值 (电感單位)

gradully = 漸進地, 逐步地

stabilized = 穩定下來.

poses : 提出 (難題難住, 使闭口无言)

peculiar : 特有的, 獨特的

opposition : 反对, 对抗.

mathematical constant : 數學常數

phase relationships : 相的関係.

vs = versus : ……对……

comparison : 比例.

power relationships : 功率関係

pulsating = 脈衝的, 光断的.

interaction : 相互作用

specific factors : 特别的因素.

essential : 主要的.

reactor = 电抗器, 反应堆

adjustment tool : 調整工具

positioning = 安置, 定位置.

threading : 拉线, 從中擠过去.

quality factor = 品質因素 (Q)

versatile : 多功能的.

array = 排列, 列隊.

EL-CT-01, -4,
EL-BC-15, -5, -9.
LIII-U12-30, -31.

ferrite-core : 氧化鉄磁心 (鉄氧化物)

reject : 拒绝, 拆.

tuned circuits : 調諧电路

resonant : 諧振的, 共鸣的.

magnetic coupling : 磁耦合

tap : 抽頭, 分接頭, 分支.

CT = center tapped 中心分支

power XMFR = 功率变压器

audio XMFR : 音頻 变压器

coupling : 耦合, 联接, 匹配, 联軸器

isolation transformer : 隔離变压器

autotransformer : 自耦变压器

impedance · 阻抗

hazard : 危险

misplaced : 錯誤放置

tingler : 刺痛, 疼 震动

performance test : 效率(性能) 測驗.

power supplies : 电力供应.

amplifier : 放大器

power distribution system : 配电系統.

consumer products : 消費產品.

neon bulb : 霓虹燈泡

inductive kick : 电感应拒绝

noticeable : 值得注意的.

influence : 影響.

developed : 发展, 產生.

produced by : 被以---產生.

coefficient : 係數 :

radian : 弧度 (弧度法的角度单位)

lag : 落後, 遲滯.

lossless : 无損失

EL-BC-16, -5, -6, -9, -12, -13

peak : 波峰. 最高奌. 使(脈衝)尖銳

disregard : 不理. 輕視

purely inductive circuit :

principle : 原理

electromagnetic induction : 电磁感应.

physical connection : 实体接連

intercept : 遮断, 截断

accomplish : 貫徹. 传授.

wax paper : 臘纸

cardboard : 卡纸板, 硬柏纸

attempt : 嘗試, 企圖.

link : 連结, 携手.

direction : 方向.

vector : 向量, 矢量. 导线电誘導

treat : 对待, 處理

in-phase : 在(進入)相位.

super-imposed : 被特強地迫制.

resistive : 电阻的. 有阻力的

predict : 預测

transformer losses : 变压器損耗

hysteresis : 滞後(现象)

copper loss : 銅(内)損(失).

saturation : 飽和.

eddy currents : 渦流电

inherent : 天性的, 固有的.

dissipated : 消散. 驅散.

distinguishes : 區别, 辨别

ELECTRONIC CURRICULUM

VOCATIONAL TRAINING [illegible]ON PLAN **#** IX

CAPACITANCE

Teaching Materials Source ____________________

Chapter __________, pages __________

Lab Manual pages __________

Additional Instructor Materials ____________________

Main concepts student will learn:	**Technical Vocabulary**	**Related General Vocabulary**	**Teaching Activity**
see attached	see Glossary	see Glossary	see attached

Materials and Notes

Length of Lesson

2 - 3 weeks

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

Main concepts the student will learn

The student will be able to:

1. to describe safety precautions to be observed to prevent electrical shock when handling capacitors in electrical circuits.

2. write the names and abbreviations of the various units of measurements for capacitance, and draw the schematic symbols for both fixed and variable capacitors.

3. define the term capacitance and list three factors which affect this property in a capacitor.

4. indicate, on a schematic drawing of a battery and a capacitor in series, the direction of the charging current and the polarity of the charge on the capacitor.

5. solve for total capacitance of capacitors either in series or parallel utilizing the proper formula and units of measurement.

6. explain and compute problems involving RC time constants and capacitive reactances while utilizing the values given and solving for the unknown.

Teaching Activity

1. The instructor should not forget to preface the presentation on capacitors with a thourough coverage of capacitor safety. In addition to stressing the possibility of capacitors causing a severe shock, explain that this voltage can seriously damage test instruments as well.

   remember to point out during a presentation that the formulas for adding capacitors in series or in parallel are exactly opposite to those for adding resistors in series or in parallel. To avoid formula confusion point out that capacitance is the ability of a device to store an amount of electrons at a given voltage, while resistance is the measure of a device to oppose current as a result of its internal structure, hence formula inconsistency.

   When discussing capacitor construction it is easy to tear apart in front of the class a discarded capacitor and describe the contents; foil, waxed paper, and covering material. A little theatrics will be far more impressive than a textbook definition.

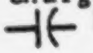
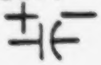
   After the class has mastered basic capacitor principles, accompanied by appropriate problem exercises, it is a good opportunity to lay the foundation for reactance. Impress on the students that reactance is AC resistance caused by a capacitor and when solving for simple electrical quantities just substitute "X_c" for "R" in the Ohm's Law equation. Remember a successful program of constant formula repetition and problem solving will pay off.

Name: ____________________

Date: ____________________

Period: ____________________

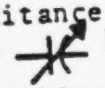
CAPACITANCE
TECHNICAL GLOSSARY

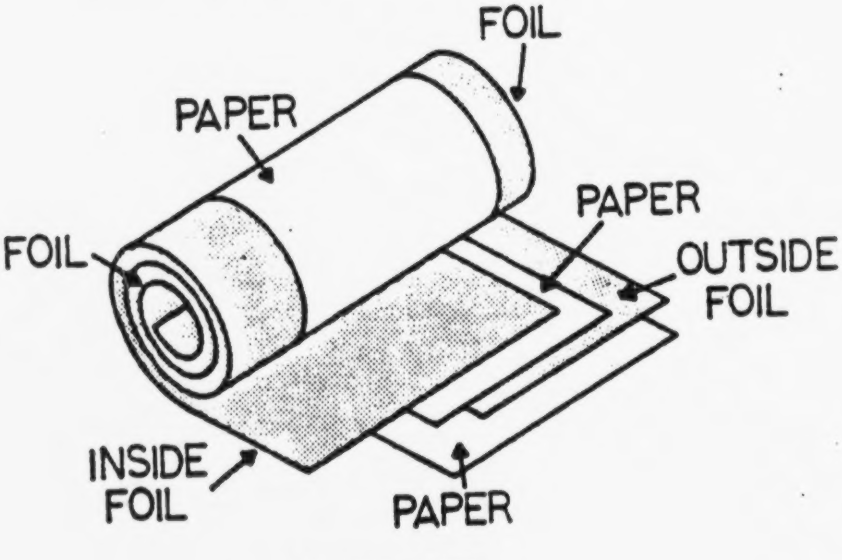
BREAKDOWN VOLTAGE:	A voltage, applied across the plates of a capacitor, which will cause the stored charges to puncture through the dielectric. Once this occurs, the capacitor is referred to as "leaky" and is considered functionally destroyed.
CAPACITANCE:	The ability of a device, usually a capacitor, to store a charge, and oppose a change in voltage. Capacitance is measured in the basic unit farads. Abbrev. C
CAPACITIVE REACTANCE:	The AC resistance of a capacitor, measured in ohms, and computed by the formula $X_C = \frac{1}{2\pi fc}$. Abbrev. X_C
CAPACITOR:	A device consisting of two metal plates separated by an insulator, or dielectric. A capacitor has the ability to store a charge and provides capacitance in a circuit. Symbol:  Letter symbol: C
DIELECTRIC:	The insulating material between the plates of a capacitor
DIELECTRIC STRENGTH:	A measurement of a dielectric materials ability to withstand high voltages without breaking down. The rating is based upon the specific thickness of the insulator.
DISCHARGE:	The process of removing or neutralizing stored charges from the plates of a capacitor.
ELECTROLYTIC CAPACITOR:	A fixed value capacitor which utilizes a thin oxide layer on the surface of one of the plates, as a dielectric. The advantage of this design is that it allows for large capacitance values and relatively small case size. These capacitors are generally polarized. Symbol:  Letter symbol: C
ELECTROSTATIC FIELD:	A field of force that exits between positively and negatively charge surfaces. It is the presence of this force that allows a capacitor to charge and remain charge for an amount of time.
FARAD:	The basic unit of measurement for capacitance. One farad is a large unit, therefore more practical units of capacitance are the microfarad and the picofarad. Abbrev. F
NONPOLARIZED:	Many capacitors may be connected into a circuit regardles of plate polarity. This type of capacitor is designated as a nonpolar or nonpolarized capacitor. Disc, paper, mica, and mylar capacitors fall into this category.
PLATE:	The conducting surfaces of a capacitor, upon which charges accumulate and/or are stored.

Name: ______________

Date: ______________

Period: ______________

POLARIZED:	Capacitor whose plates have a particular polarity assigned to them. When connecting a polarized capacitor, the + plate must be connected to the positive side of the circuit, while the - plate is connected to the negative side of the circuit.
RC TIME CONSTANT:	Measurement of the time, in seconds, that it takes for a capacitor to charge to 63.2 percent of the source voltage. This time is a function of the circuit resistance and capacitance, as expressed by the following formula: T = R x C. It requires 5 time constants for a capacitor to be considered fully charge.
REACTANCE:	The opposition to AC current flow due to capacitance or inductance.
TEMPERATURE COEFFICIENT:	A capacitor rating which designates the change in capacitance due to variations in operating temperature. It is usually expressed as a change in capacitance per degree celsius.
VARIABLE CAPACITOR:	A type of capacitor whose capacitance can be varied by some mechanical means. Symbol:  Letter symbol: C
WORKING VOLTAGE:	Generally designated as WVDC (working voltage direct current), and is a measure of the maximum DC voltage tha may be applied continuously to a capacitor without risking breakdown, or permanent damage. To compute WVAC simply multiply .707 time the WVDC rating. Abbrev. WV, WVDC, or VDC.



CAPACITOR

Name: ______________________

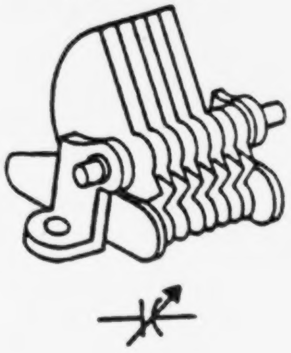
Date: ______________________

Period: ______________________

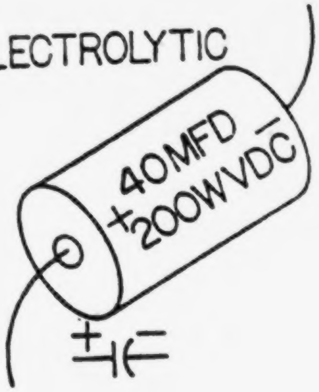
INFORMATIONAL HANDOUT

CAPACITORS - WHAT THEY ARE AND HOW THEY FUNCTION

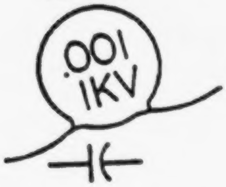
VARIABLE



ELECTROLYTIC



DISC



GENERAL INFORMATION:

In its basic form, the capacitor consists of two conducting areas, such as two metal plates or foil sheets, separated by an insulator, such as air, paper, or plastic. The insulator is called a dielectric. A capacitor has the "capacity" for storing an electrical charge, hence its name. Years ag capacitors were sometimes called condensers and you still might encounter this name in older magazines and books.

Capacitors can serve as filters, and are utilized for DC blocking and AC signal coupling. Combined with coils to form resonant circuits, they are used for tuning to specific signal frequencies. They are available in bot fixed and variable form, with the latter used principally for tuning RF circuits in receivers and transmitters.

Fixed capacitors generally are identified by the type of dielectric used, or their basic shape. Variable capacitors may be designed for varying plate area, or varying distance between the plates, with the latter calle trimmer or padder capacitors, and the former (plate area) called a rotary capacitor.

Here are the basic capacitor specifications with which you should be familiar:

TYPE: Refers to the type of dielectric used in the capacitor's construction. Fixed capacitors may be paper, mylar, ceramic, or electrolytic, et Occasionally, type also refers to the physical shape of the capacitor. F example, one might refer to a disc (shape) ceramic (dielectric) capacitor. As a general rule, a capacitor's physical shape is not critical from an electrical viewpoint, but may be a factor in circuits where space is at a premium.

Name: ____________________

Date: ____________________

Period: ____________________

meter across the capacitor observing polarity. Electrolytic capacitors will have a measurable, high resistance between their terminals, even if they are in good condition, as a rule of thumb, electrolytic capacitors with a WVDC rating of 100 volts or more usually have a resistance in excess of 300,000 ohms, while capacitors with a WVDC rating of less than 100 volts will have a resistance of from 100,000 to 500,000 ohms. Variable capacitors are checked in a similar manner to nonelectrolytic capacitors, the meter response should be similar. When testing a rotary style capacitor, begin with the plates fully meshed, and slowly unmesh the plates, watching the meter for indications of shorts. In some cases, a shorted condition can be corrected by carefully bending the shorted plates away from each other.

2. Checking for open capacitors. The capacitor tester may be used to perform an open test on a capacitor. If a capacitor checker is not available, the simplist way to accurately check a suspected capacitor is by substitution. Because of the characteristics of open circuits, this can be done simply by connecting a good capacitor in parallel with the existing circuit capacitor. There is no need to remove the suspect capacitor from the circuit, and a simple technique is to use alligator clip leads for "connecting in" the test capacitor. If that eliminates the problem, you know the original should be replaced.
3. Leakage test. This test is reserved almost exclusively for a capacitor checker, although special circuits can be built for checking leakage. If neither of these possibilities are feasible, direct substitution can be used. This will involve removing and replacing a suspect capacitor with a good capacitor of like value.
4. Value test. Used to determine the farad value of the capacitors, and requires the use of a capacitor tester.

USES FOR CAPACITORS:

After all this discussion on capacitors, it might be a good idea to find out what they are used for. The capacitor is an extremely versatile device and can be used to perform a number of different circuit functions. For example:

1. The ability of a capacitor to store a charge at one time, and release that charge at a later time, makes the capacitor useful in the operation of a photostrobe, welding units, and capacitive discharge ignition systems for automobiles.
2. The ability to control the timing of the charging and discharging cycles makes the capacitor applicable for precise timing circuits such as used in oscillators and strobe lights.
3. Capacitors are also used to block the flow of DC current, and couple signals from one circuit to another. This process is used commonly in multistage amplifiers where the coupling capacitor allows the AC signal to flow to the next stage, but blocks the DC current flow into that succeding stage. If the DC current were allowed into the next stage, operating points would change, and distortion would occur.
4. Capacitors are used as filtering elements in DC power supplies to smooth out and flatten the output current and voltage.

Name: ____________________

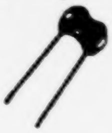
Date: ____________________

Period: __________________

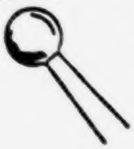
5. Capacitors, in combination with inductors and/or resistors form tuned circuits, which are frequency selective devices. These circuits will accept or reject a certain frequency or band of frequencies. These circuits are used as tuning circuits for radios, televisions and transceivers.

COMMON CAPACITORS AND APPLICATIONS

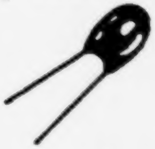
○ Silver mica capacitor - is a precision capacitor for circuits requiring close tolerance, stability, dependability.



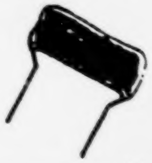
⬡ Disc capacitor - is suited for transistor circuits and minature assemblies.



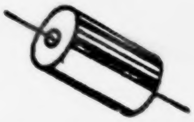
□ Tantalum capacitor - used in timing circuits and wherever low-leakage, high stability and precision is required.



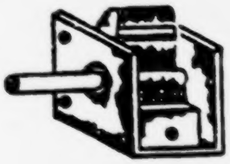
△ Mylar/Paper capacitor - is a standard "by-pass" type capacitor exhibiting good heat and moisture resistant properties.



⬡ Electrolytic capacitor - used in transistor circuits and other voltage applications requiring high capacitance values.



□ Variable capacitor - used primarily in tuning circuits and wherever a variable capacitance is required. Dielectric is generally "mylar" or air.



Name: ____________________

Date: ____________________

Period: ____________________

Capacitors utilize two electrical ratings, one the capacity rating in farads and the other a working voltage rating.

CAPACITY: The actual electrical value of the capacitor is specified either in microfarads (Abbreviated as μF, MF, mfd, or MFD) or picofarads (pF, Pf, or pFd). A picofarad is one-millionth of a microfarad and was once designated micromicrofarad (mmf, Mmf, or mmF). You can convert microfarads into picofarads and vice-versa simply by moving the decimal point 6 digits to the left or right, as appropriate. For example, 0.001 μF is the same as 1000 pF. Many times disc capacitors give capacity rating as just a number with no indication of unit (μF or pF), generally the rating will be in picofarads.

WORKING VOLTAGE: Indicates the maximum DC operating voltage to which the capacitor may be subjected. A capacitor of higher working voltage can be substituted for one with a lower voltage of the same value (capacity). Thus, a 600-volt mylar capacitor may be used as a direct replacement for a 200-volt unit of the same value.

TOLERANCE: Given as a percentage figure, indicates the possible variation in a capacitor's actual value from its specified nominal value. Most capacitors have a tolerance of 20%. Thus, a 10 μF electrolytic capacitor with a 20% tolerance might have an actual value of from 8 to 12 μF.

LEADS: The principal designations are: axial, which means the leads extend at opposite ends along the length of the device; parallel or PC, which means the leads extend together from one end of the unit.

CAPACITOR SAFETY:

Many capacitors, especially electrolytic capacitors used as filters, retain their charges for many hours after the circuit is turned off. Because a potentially dangerous voltage may exits across the capacitor plates a few simple precautions should be observed:

1. Always treat a capacitor as if it were charge.
2. Never grab a capacitor by the leads, handle by the case only.

Name: ____________________

Date: ____________________

Period: ____________________

3. When working with circuits which contain high voltage capacitors, discharge them immediately before the circuit is handled.
4. When discharging a capacitor use an insulated wire to briefly short the leads of the capacitor together. Handle your shorting wire by the insulation only. To reduce sparking, a 10,000 ohm resistor can be connected in series with the wire, the discharge will take a little longer in this case.
5. In many older style television receivers, the picture tube is used as a giant capacitor, with 20,000 volts or more stored on its plates. Discharge by connecting a shorting wire between the metal chassis and the outer surface of the picture tube. Move the shorting wire to touch several spots on the tube surface.

Capacitors are also prone to another danger, that of exploding. Two conditions will cause a capacitor to explode with dangerous results 1) too high of a voltage applied across the plates, and 2) connecting an electrolytic capacitor into a circuit with reverse polarity. After assembling or repairing a circuit double check to:

1. Be sure electrolytic capacitors are connected correctly into the circuit, with the + terminal connected to the positive side of the circui and the - terminal to the negative side of the circuit.
2. Compare the circuit voltage with the WVDC rating of the capacitor. It is a good practice to allow a 100% safety margin. That is, if the circuit voltage is 50V the capacitor should have at least 100 WVDC rating.

CAPACITOR TESTING:

There are two basic types of capacitor checks - a condition test, and a value test. The condition tests are used to check the physical condition of the capacitor - shorts, leakage, or opens. The value test is used to determine the electrical - farad - value of the capacitor. An instrument called a capacitor tester or analyzer can perform both condition and value tests, but these instruments are not always readily available.

Your ohmmeter may be used to perform condition tests as outlined below:

1. Testing for shorts using an ohmmeter. A simple continuity test can be used to test for shorts. Isolate the capacitor from the circuit by disconnnecting at least one of the leads. As a precaution, the capacitor should first be discharged to prevent possible damage to the meter, or a dangerous shock to the technician. When testing a nonelectrolyti capacitor an extremely high resistance value should be indicated when the test leads are connected across the capacitor. Procedure: adjust the ohmmeter to a high range position and connect the leads across the terminals of the capacitor. Good nonelectrolytic capacitors will exhibit extremely high resistance or no continuity, if zero ohms, or low resistance is indicated the capacitor is shorted and should be replace When testing electrolytic capacitors for shorts you must first learn the polarity assigned to the leads of your ohmmeter, then connect the

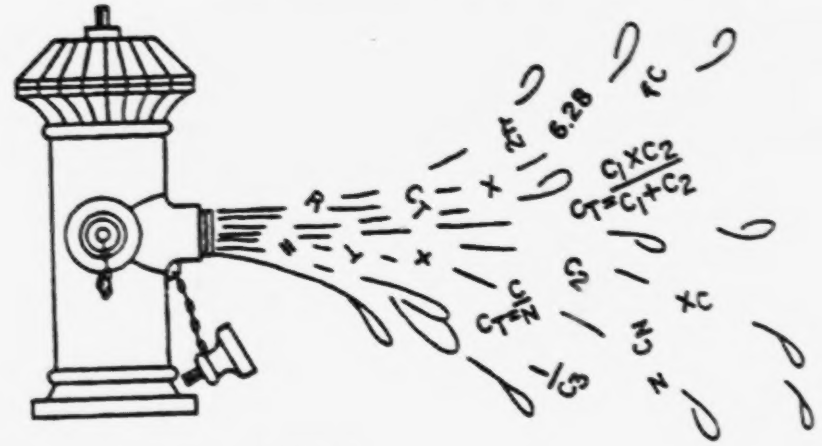
Name: ____________________

Date: ____________________

Period: ____________________

INFORMATIONAL HANDOUT

CAPACITANCE FORMULAS



CAPACITORS IN SERIES AND PARALLEL:

SERIES FORMULAS:

When capacitors are connected in series the total effective capacitance decreases, thus C_T will always be lower than the value of the smallest "farad value" capacitor in the series string.

Total Capacitance - (Equal capacitor values) $C_T = \frac{C}{N}$ $\frac{\text{capacitance of one capacitor}}{\text{number of capacitors}}$

- (Two capacitors unequal value) $C_T = \frac{C_1 x C_2}{C_1 + C_2}$

- (General formulas)

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}$$

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}}$$

Note the similarity of these formulas to the parallel resistance. formulas.

Series connections may be used to increase the effective working voltage of a block of capacitors, or to obtain special values, but, this requires special considerations and/or techniques.

Name: ______________

Date: ______________

Period: ______________

PARALLEL FORMULA:

When capacitors are connected in parallel the total effective capacitance increases, thus C_T will always be larger than the largest "farad value" capacitor.

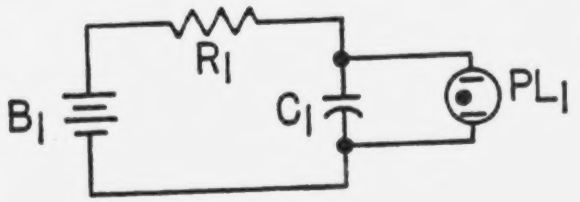
Total Capacitance - $C_T = C_1 + C_2 + C_3 + \cdots + C_N$

Note the similarity of this formula to the series resistance formula.

Parallel connections may be used to obtain special values. Use similar types of capacitors with the same working voltages.

R-C TIME CONSTANTS:

An R-C network contains a resistor connected in series with a capacitor. This basic circuit forms a simple timing or oscillator circuit.



RELAXATION OSCILLATOR

The rate at which the capacitor charges or discharges is dependent upon the capacitance and resistance present in the circuit. The higher the resistance or capacitance, the longer the charge time.

TIME CONSTANT FORMULA:

$T = R \times C$

Where T = time in seconds

R = resistance in ohms

C = capacitance in farads

Recall that one time constant (1T) is the time required to charge the capacitor to 63.2% of full charge. To fully charge a capacitor in an RC network requires 5 time constants. Capacitors charge at the rate listed in the chart below.

Time Constant	Percent of Maximum Voltage
1T	63.2%
2T	86.4%
3T	94.9%

Name: ______________

Date: ______________

Period: ______________

4T· 98.1%
5T· 100%
Effectively

After each time constant the voltage increases to a value 63.2% closer to its maximum value.

Recall the maximum voltage is equivalent to the source voltage.

CAPACITIVE REACTANCE:

Capacitors block direct current, but permit alternating current to "flow." Capacitors have a unique resistance to the flow of alternating current; this resistance is called capacitive reactance.

FORMULA:

$$X_C = \frac{1}{2\pi \times f \times C}$$

Where X_C = capacitive reactance in ohms

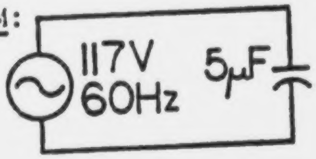
2π = 6.28, a mathematical constant

f = frequency in hertz

C = capacitance in farads

From the formula one can readily see that an increase in either frequency or capacitance will decrease the capacitive reactance.

SAMPLE PROBLEM:



At a frequency of 60Hz what is the capacitive reactance of a 5μF capacitor?

Note 5 mfd equals .000005 farad

Step 1: $X_C = \frac{1}{6.28\ fC}$ This is the formula.

Step 2: $X_C = \frac{1}{6.28 \times 60 \times .000005}$ Here we have substituted actual values for f and C. f in hertz, C in farads.

Step 3: $X_C = \frac{1}{.0018840}$ Here we have multiplied all the figures together.

Name: ______________

Date: ______________

Period: ______________

Step 4: $X_C = 530.7$ ohms

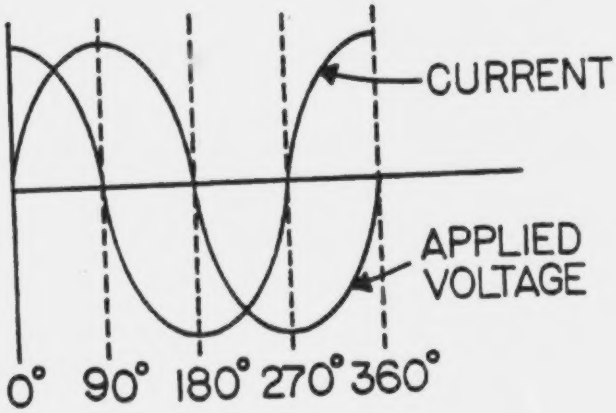
To solve the fraction in Step 3, we divided 1, the figure above the line by the figure .0018840, and adding seven zeroes after th figure 1 to compensate for moving the decimal point seven plac to the right in converting the number .0018840 to a whole numbe

Divide $\frac{1}{.0018840} = \frac{10,000,000}{18,840}$

PHASE RELATIONSHIP:

Recall that phase relations deal with a comparison between the voltage and current waves in an AC circuit. In an AC resistive circuit you learned that voltage and current are in-phase, that is the voltage wave follows directly the current wave, in a capacitive AC circuit this condition does not occur.

When an AC voltage is applied across a capacitor, maximum current flows in the circuit the instant the source is energized. (Remember what you learned about the charging of a capacitor in a DC circuit) thus, we will find that current will lead the applied voltage by 9



INFORMATION SHEET 1

COMPARISON OF COMMON TYPE CAPACITORS

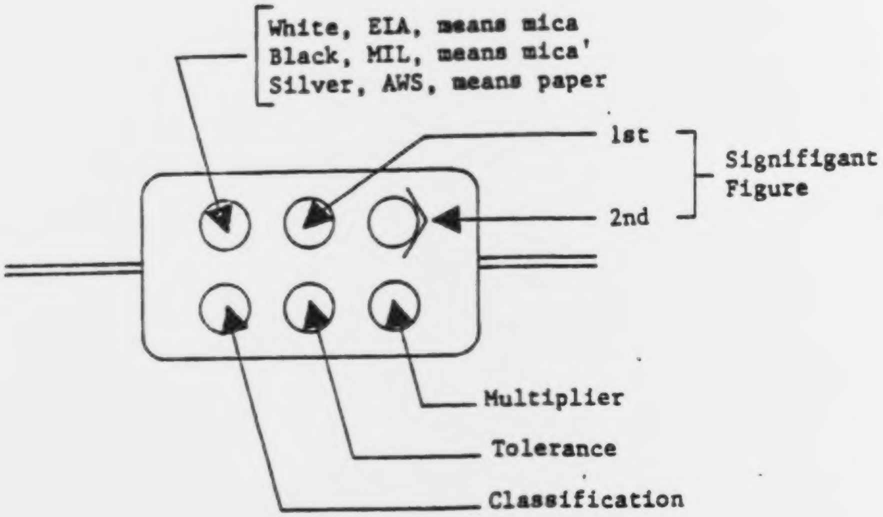
DIELECTRIC	CONSTRUCTION	CAPACITANCE	BREAKDOWN, V
Air	Meshed plates	10 - 400 p F	400 (0.02 in air gap)
Ceramic	Tubular	0.5 - 1,600 p F	500 - 20,000
	Disk	0.002 - 0.1 μ F	
Electrolytic	Aluminum	5 - 5,000 μ F	10 - 450
	Tantalum	0.01 - 300 μ F	6 - 50
Mica	Stacked sheets	10 - 5,000 μ F	500 - 20,000
Paper	Rolled foil	0.001 - 1 μ F	200 - 1,600

CAPACITOR COLOR CODING

Mica and tubular ceramic capacitors are color-coded to indicate their capacitance value. Coding is necessary only for the small sizes; therefore, the color-coded capacitance value is always in pF units. The colors used are the same as for resistor coding.

MICA CAPACITORS

Mica capacitors generally use the present six-dot system shown below. Old systems have been used and are described in the Appendix of electronic texts.


White, EIA, means mica
Black, MIL, means mica'
Silver, AWS, means paper
1st
2nd
Signifigant
Figure
Multiplier
Tolerance
Classification

INFORMATION SHEET 1 (cont'd)

Place the arrow on the top row pointing to the right.

Read top row from left to right and bottom row from right to left.

First dot indicates specifications or standard of the capacitor.

Second and third dot indicate the two significant figures of the capacitance value.

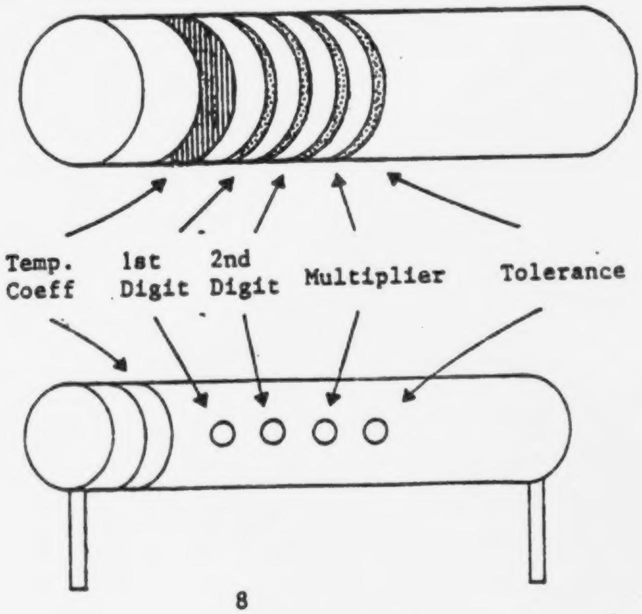
The fourth dot is the multiplier of the capacitance value.

The fifth dot indicates the tolerance of the capacitance value.

The sixth dot indicates the EIA class; there are seven classes from A to G specifying temperature coefficient, leakage resistance, and additional variable factors.

TUBULAR CERAMIC CAPACITORS

Tubular ceramic capacitors use the coding system with five color bands or dots, as follows:



INFORMATION SHEET 1 (cont'd)

The wide color band specifying the temperature coefficient indicates the left end.

The next three bands or dots indicate the capacitance value. Mica capacitors range from 10 to 5,000 pF and small tubular capacitors from 0.5 to 1,000 pF.

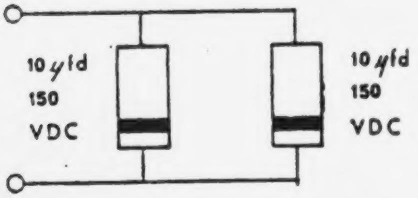
The last band or dot indicates the tolerance of the capacitance value.

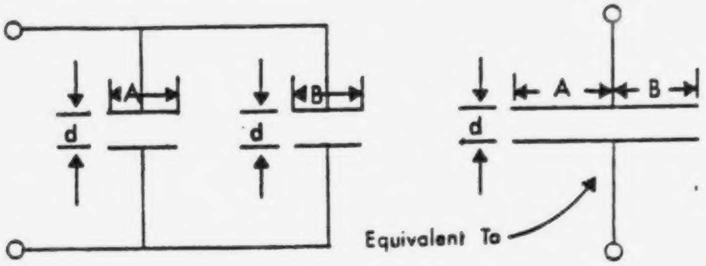
Color codes for the above are in the Appendix of most electronics texts.

INFORMATION

Information sheet 2

CAPACITORS IN PARALLEL


10 µfd
150
VDC
10 µfd
150
VDC

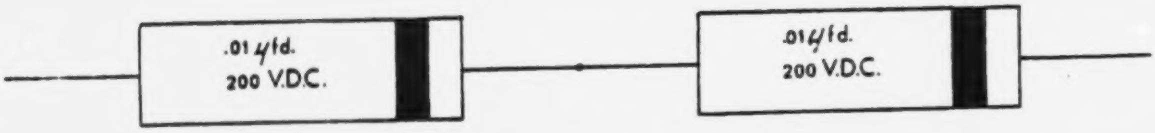

d
A
d
B
d
A
B
Equivalent To

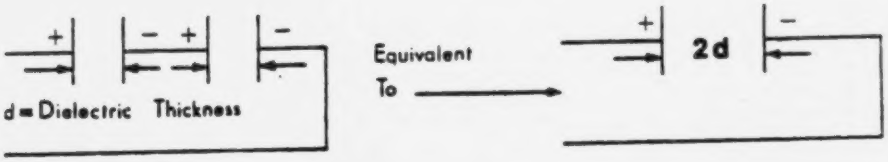
When capacitors are connected in parallel, the effect is equivalent to having one capacitor with a larger plate with the same dielectric thickness. The two effects of this are:

1. The breakdown voltage or working voltage remains the same, as the smallest.
2. The combined or total capacitance is equal to the sum of the capacitors placed in parallel.

$$C_T = C_1 + C_2 + C_3 + \ldots C_N$$

CAPACITORS IN SERIES


.01 µfd.
200 V.D.C.
.01 µfd.
200 V.D.C.


+
− +
−
d = Dielectric Thickness
Equivalent To
+
2d
−

Information sheet 2 continued.

a. When capacitors are connected in series, the effect is equivalent to one capacitor with a thicker dielectric. The thickness of the dielectric is increased by the number of capacitors in series. There are two important effects of increasing the thickness of the dielectric:

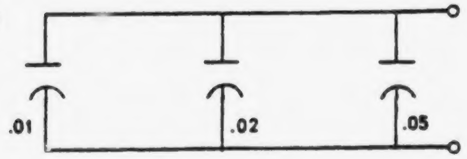
1. The breakdown or working voltage is increased. This is a major advantage of series capacitance, and normally capacitors of the same size and voltage rating are used. When this is done, the combined breakdown voltage will be equal to the sum of the individual breakdown voltages. When unequal capacitance are used in series the voltage drop across each capacitor is inversely proportional to its capacitance. This must be individually compared to the voltage rating of the capacitor, which must not be exceeded. This is beyond the scope of this package and will be covered later in a package on voltage dividers.
2. The capacitance is decreased. The combined or total capacitance will be

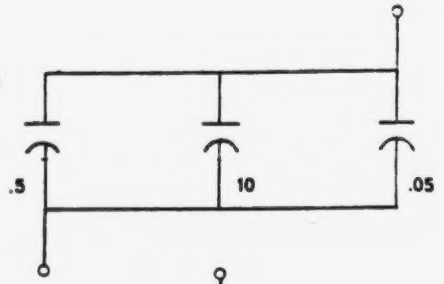
$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \quad \ldots \frac{1}{C_N}}$$

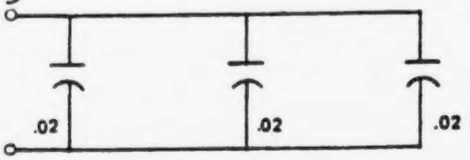
EXERCISE #1

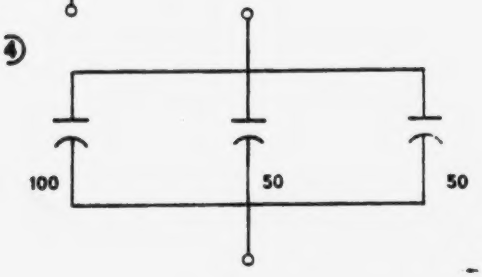
Directions:

Determine the total capacitance of the following capacitors placed in parallel. Do not write the formula, try to memorize it. All sizes are in μF.

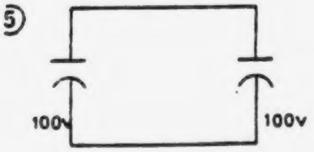
1)


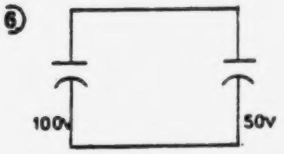
2)


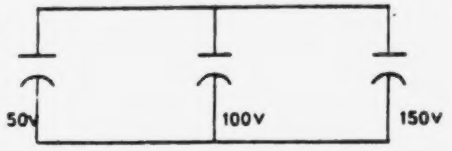
3)


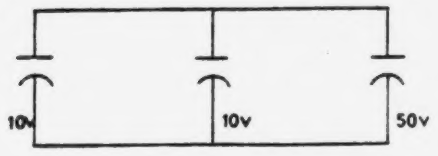
4)


What is the breakdown or working voltage of the following capacitors?

5)


6)


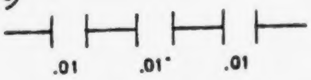
7)

50v
100v
150v

8)


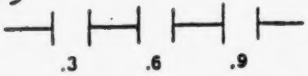
Exercise #1 continued.

Determine the total capacitance for the following capacitors placed in series. All sizes are in μF.

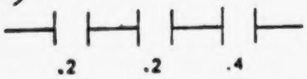
9)



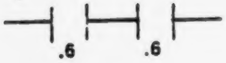
10)



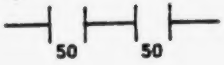
11)



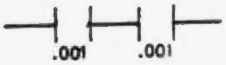
12)



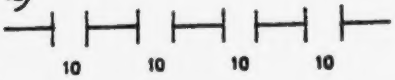
13)



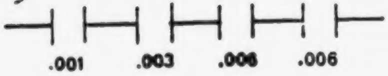
14)



15)



16)

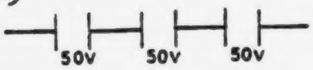

.001
.003
.006
.006

Examination of your answers with the above problmes should prove the two following statements concerning capacitors in series.

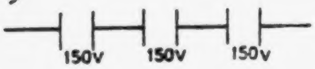
1. The total capacitance is always smaller than the smallest capacitor in a series circuit.
2. When capacitors of the same size are placed in series, the total capacitance is equal to the value of one of the capacitors divided by the number of capacitors in parallel. $C_T = \frac{C\ (\text{common})}{n}$

Determine the working voltage for the following same sized capacitors placed in series.

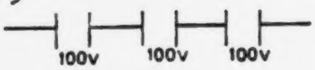
17)



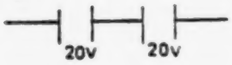
18)


150v
150v
150v

19)


100v
100v
100v

20)



Problem sheet# ____

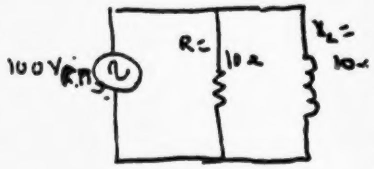
Parallel RL circuits/Parallel RC circuits

Text: Grob ch.20 pg 400
: Grob ch 23 pg 461

Prob #1 (Art. 20-4)
Solve for:

I_R ________ Z ________
I_{X_L} ________ α ________
I_t ________

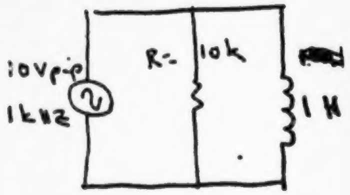
VECTOR DIAGRAM


100V RMS
R=
10Ω
X_L=
10Ω

CIRCUIT

Prob #2 (Art. 20-4)
Solve for

I_R ________ Z ________
I_{X_L} ________ α ________
I_t ________


10Vp-p
1kHz
R=
10k
1 H

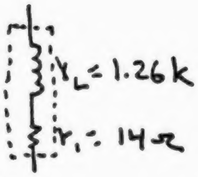
Vector DIAGRAM

Prob #3 (READ Article 20-5)

Solve for Q ________
Define: Skin effect - ________

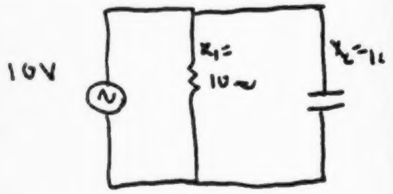
r_i - ________

R_e - ________


X_L = 1.26k
r_i = 14Ω

Prob. #4 (Art 23.3, 23.4)
Solve for

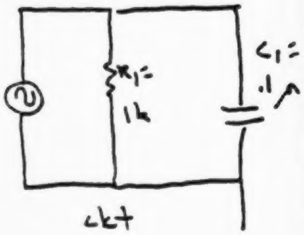
I_R = ________ Z = ________
I_C = ________ α = ________
I_t = ________


10V
R_1=
10Ω
X_C=1k

ckt

Problem #5 (Art 23.3, 23.4) VECTOR DIAGRAM
Solve for

I_R = ________ Z = ________
I_C = ________ α = ________
I_t = ________



ckt

Electronics 30 Homework 10

Grob 5th edition -----> Read chapter 20 and 21. Do problems (chapter 20) 1 thru 4 and 6 thru 11 on pages 410 and 411.

or -

Grob 4th edition -----> Read chapter 21 and 22. Do problems (chapter 21) 1 thru 6 and 8 thru 14 on pages 438 and 439.

---

1. Find: (FIG1)

$Z\angle\theta$ __________ ohms∠degrees

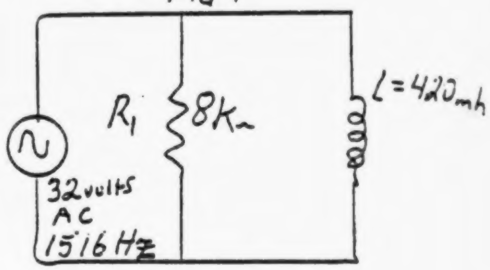
$I\theta$ __________ degrees

I_t __________ ma

I_{X_L} __________ ma

I_R __________ ma

FIG 1


R1
8K~
L=420mh
32 volts AC 1516 Hz

2. FIND: (FIG2)

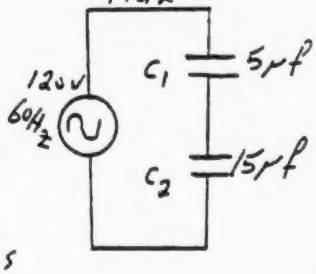
C_t __________ uf

X_{C_1} __________ ohms

X_{C_2} __________ ohms

X_C total __________ ohms

FIG 2


120v
60Hz
C1
5uf
C2
15uf

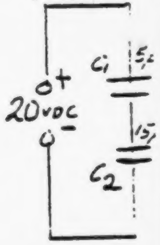
3. FIND: (FIG3)

V_{C_1} __________ Volts

V_{C_2} __________ Volts

Q_t __________ coulombs

Fig 3


+
20vDC
−
C1
5
C2
15

i- FIND: (FIG 4)

C total __________ uf

C2 and C3 are nanofarads

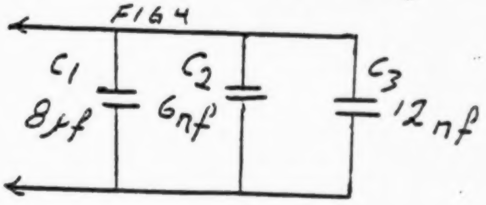


FIG 4
C1
8uf
C2
6nf
C3
12nf

5. FIND: (FIG5)

Z __________ K~

θ __________ °

I_t __________ ma

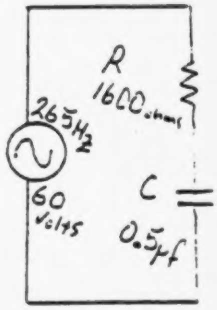
V_R __________ Volts

V_c __________ volts

pf __________

True Pwr __________ watts

Volt Amperes __________ VA

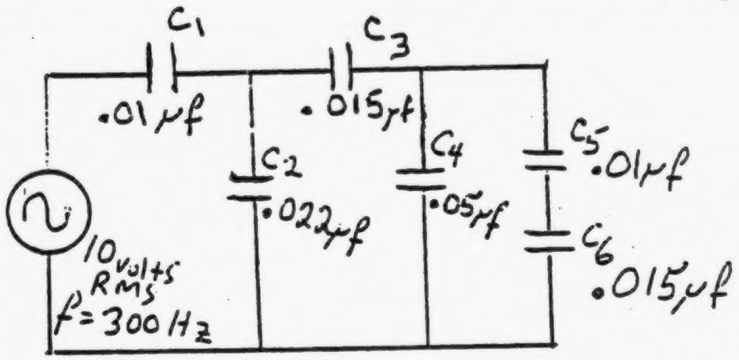

R
1600 ohms
265Hz
60 Volts
C
0.5uf

Electronics 30 Homework 11

Grob 5th edition -----> Read chapter 22 Do problems 1 thru 17 (chapter 21) on pages 424 and 425 and 1 thru 14 (pages 439 and 440) at end of ch 22.
or -
Grob 4th edition -----> Read chapter 23 Do problems 1 thru 18 (chapter 22) on pages 455 and 456 and 1 thru 13 (pag 470) at end of ch 23.

---

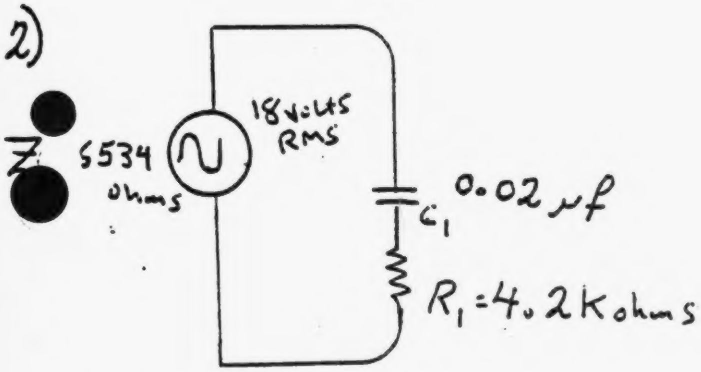
1)


C_1
.01 µf
C_3
.015 µf
C_2
.022 µf
C_4
.05 µf
C_5
.01 µf
C_6
.015 µf
10 volts RMS
f = 300 Hz

FIND:

V_{C_1} ______________ Volts X_{C_1} ______ Kohms
V_{C_2} ______________ Volts X_{C_2} ______ Kohms
V_{C_3} ______________ Volts X_{C_3} ______ Kohms
V_{C4} ______________ Volts X_{C4} ______ Kohms
V_{C5} ______________ Volts X_{C5} ______ Kohms
V_{C6} ______________ Volts X_{C6} ______ Kohms
C total ______________ Nf I_t ______ m
$X_{C\ total}$ ______________ ohms

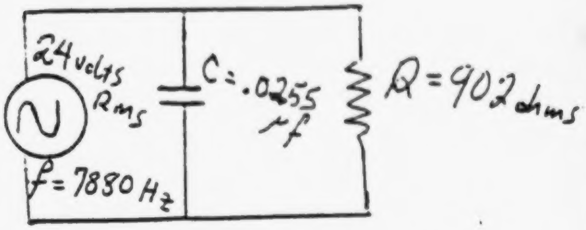
2)


Z 5534 ohms
18 volts RMS
C_1 0.02 µf
R_1 = 4.2 Kohms

FIND:

θ ______________ degrees
applied freq ______________ Hz
X_c ______________ ohms
V_c ______________ Volts
True pwr ______________ mw

3)


24 volts Rms
f = 7880 Hz
C = .0255 µf
R = 902 ohms

Find:

Z ______________ ohms
θ ______________ degrees
I_t ______________ ma
True pwr ______________ mw

EXPERIMENT

EXPERIMENT #1

MATERIALS:

Old paper capacitor from obsolete TV or radio

PROCEDURE:

1. Carefully disassemble an old paper capacitor to physically identify its major components. Briefly describe them.

   Plates ____

   ____

   Dielectric ______________________________________

   ____

   Connecting leads__________________________________

   ____

2. Research to find as many different types of capacitors as possible for identification. Draw a simple sketch and schematic diagram for each type located. Include the following common types.

   Air, fixed

   Air, variable

Experiment #1 continued.

Mica, fixed

Paper, tubular

Paper, encapsulated type

Ceramic, disk

Experiment #1 continued.

Ceramic, tubular

Electrolytic, multiple section

Electrolytic, low voltage

EXPERIMENT

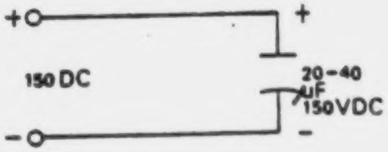
EXPERIMENT #2

MATERIALS and EQUIPMENT:

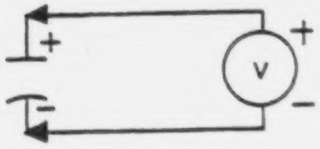
DC power supply
VTVM
Electrolytic capacitors 20-40 µF, 450 V

PROCEDURE:

1. Set power supply for 150 V DC output.
2. With leads, carefully connect capacitor to output terminals of power supply. CAUTION: Observe polarity. Positive lead of capacitor must be connected to positive terminal of power supply in order for the capacitor to function.



3. The spark and snapping noise you heard at the instant the capacitor was connected to the power supply was the instantaneous charging of the capacitor. There was a large surge of charging current at that instant because there was no resistance for this current to flow through.
4. Carefully disconnect the capacitor from the power supply. CAUTION: Handle with care as this is a charged capacitor, which will give you a little jolt if it discharges through you.
5. Set the VTVM on the 150 V DC scale and measure the charge stored in the capacitor.



Capacitor Charge______________________________ Volts

Experiment #2 continued.

NOTE: As you measure the capacitor the voltage will decrease slowly, some faster than others. This is due to two discharge paths. One through the capacitor dielectric of approximately 500 KΩ (Some capacitors will leak more than others) and the other through the VTVM of 11 MΩ. The majority of this decrease then is due to leakage through the capacitor.

6. Repeat the experiment several times charging the capacitor and measuring the capacitor charge.
7. Measure the time for the capacitor to discharge by leakage. Charge the capacitor to 150 V and then measure the time it takes to discharge to the following voltage levels:

Voltage	Time
150 V	start
125	______
100	______
75	______
50	______
25	______
0	______

When did it discharge at the fastest rate?

EXPERIMENT

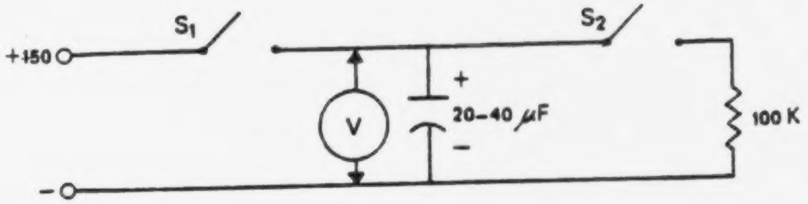
EXPERIMENT #3

MATERIALS AND EQUIPMENT:

DC Power supply
VTVM
Electrolytic capacitor 20-40 μF, 450V, 100, 1K, 100 KΩ resistors
Resistor 100K, 1K, 100Ω

PROCEDURE:

1. Connect the following circuit:



2. Apply 150 V DC to the capacitor by closing S_1.
3. Open S_1 - capacitor is now charged.
4. Close S_2, which provides a 100 K discharge path for discharging the capacitor. Measure and record the time for complete discharge. Charge and discharge several times to get a good estimate of the discharge time.

Discharge Path	CALC Time	MEAS
100 K	10 SEC.	____
1 K	____	
100 Ω	____	
0 Ω	____	

5. Replace the 100 K resistor with a 1 K resistor and repeat steps 2, 3, and 4 above. Record discharge time through the 1 KΩ resistance path.
6. Repeat for the 100 Ω resistor.
7. Repeat for 0Ω (shorted with a wire).
8. What general conclusion can you come to regarding the discharge of a capacitor?

EXPERIMENT

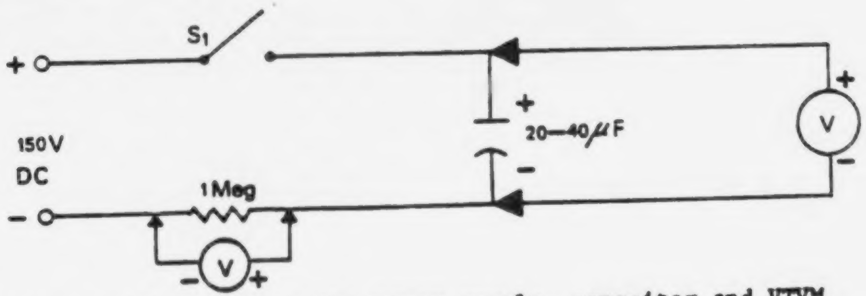
EXPERIMENT #4

MATERIALS AND EQUIPMENT:

DC Power supply
2-VTVM
Electrolytic capacitors 20-40 µF, 450V, 1 MΩ resistor
Resistor 1 Megohm

PROCEDURE:

1. Connect the following circuit.



CAUTION: observe polarities on the power supply, capacitor and VTVM.

2. Informational note: The 1 Meg resistor and VTVM will function as a microammeter. The charging current will flow through the resistor creating a voltage drop equal to IR (Ohm's Law E = IR). If we measure this voltage we can compute the current through the resistance. Since the resistance is one meg (one million) for every volt we measure there must be one millionth of an ampere or one µA.

Example: For 1 volt measured across the 1 Meg Ω resistor:

$$I = \frac{E}{R} = \frac{1}{1,000,000} = \frac{1}{1 \times 10^6} = 1\ \mu A$$

For 25 V measured across the 1 Meg Ω resistor:

$$I = \frac{E}{R} = \frac{25}{1,000,000} = \frac{25}{1 \times 10^6} = 25\ \mu A$$

If a 1 K resistor were used then the measurement would be in milliamperes/volt:

$$I = \frac{E}{R} = \frac{1}{1000} = \frac{1}{1 \times 10^3} = 1\ mA$$

Experiment #4 continued.

3. Be certain the VTVM's are on the 150 V DC range. Close the switch S_1 and observe the VTVM measuring the charging current in μA, and the VTVM measuring the charge on the capacitor. Record below:

Time	Charging Current	Capacitor Charge
S_1 closed-start of charging	____________ μA	____________ 0 V
Charging completed	____________ μA	____________ V

NOTE: The charging current never goes completely to zero. This is due to the leakage current flowing through the dielectric, which is being replaced by the power supply. The minimum charging current is the leakage current with 150 V applied.

4. Disconnect the circuit and discharge the capacitor.

EXPERIMENT

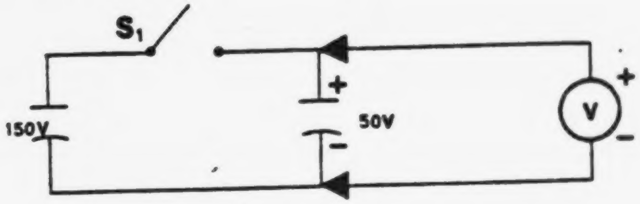
EXPERIMENT #5

MATERIALS AND EQUIPMENT:

2 - DC power supplies (one can be used)
2 - electrolytic capacitors 20-40 μF, 450 V

PROCEDURE:

1. Set the output of one power supply at 150 V and the other at 50 V.
2. Question: If the following two capacitors of the same size, one charged to 150 V and the other to 50 V, are placed in parallel by closing of the switch S_1, what will happen? What will the charge voltage be measured across the two capacitors?



3. Verify or disprove your analysis by performing the experiment. Record the measured charge voltage. ____________

   Did this verify your analysis? ____________

   Why? ____________________________________

4. How does this relate to the statement that a capacitor will charge or discharge to the potential of the applied voltage?
   ____
   ____
   ____
   ____
   ____

EXPERIMENT

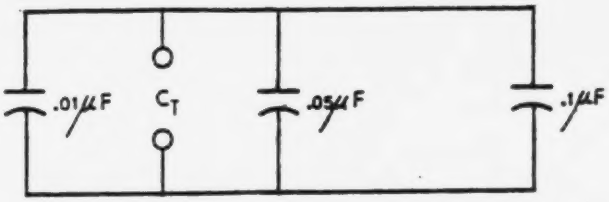
EXPERIMENT #6

MATERIALS AND EQUIPMENT:

Capacitor checker
.01, .05, .1 µF capacitors

PROCEDURE:

1. Compute the combined total capacitance (C_T) for the following capacitors connected in parallel. Show formula and work.



CT =

2. Verify your calculations by connecting three capacitors in parallel and measuring their combined total capacitance with a capacitor checker. Record.

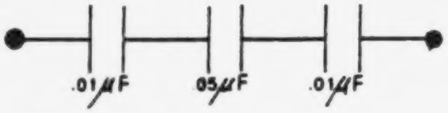
Measured C_T = ________________

Did the measurement verify your calculations? ________________

What was the difference between the computed C_T and measured C_T? __________

Can you account for the difference?

3. Compute the total capacitance of the following capacitors. Show formula and work. (Capacitors connected in series)



CT =

Experiment #6 continued.

4. Verify your calculations by connecting capacitors in series and measuring their total capacitance with a capacitor checker.

Measured C_T = ____________________.

Did this measurement verify your calculations? ____________________

How does the total capacitance compare with the size of the smallest capacitor, (the .01 μF)?

____

____

____

Would this relationship hold true for all capacitors connected in series? Why?

____

____

____

EXPERIMENT

EXPERIMENT #7

MATERIALS AND EQUIPMENT:

ohmmeter
100 pF, .01 μF, .1 μF capacitors; 10 μF, 40 μF electrolytic capacitors

INFORMATIONAL NOTES:

1. Defective capacitors are either open or shorted. An open capacitor is when the capacitor leads are not making electrical contact with the plates and the capacitor will not charge. A shorted capacitor is when the dielectric has broken down, arced across and there is low resistance path from one plate to the other. A leaky capacitor is one that does not have a direct short but has resistance lower than normal.

2. An ohmmeter can be used to check for these defects, but only under a voltage charge of 1½ V. A capacitor could check good with the ohmmeter but still break down under a higher working voltage, but not often.

PROCEDURE:

1. Set the ohmmeter to the Megohm scale. This places a high resistance in series with the 1½ volt battery, which will give the meter needle a larger deflection when checking smaller capacitors.

2. Connect the ohmmeter leads to the .1 μF capacitor and note the meter needle deflection. A normal capacitor will cause the needle to deflect down scale as it starts to charge and then the needle will move back up scale as the charging current decreases. When the capacitor is fully charged, the ohmmeter indicates the resistance of the dielectric. (Normally 500-1000 MΩ for all except electrolytics which have approximately 500 K resistance.) The amount of initial charging current is also a rough indication of the size of the capacitor. For comparison of capacitors note and record how far down scale the needle deflects, and the resistance when charging is completed.

Experiment #7 continued.

Capacitor	Needle deflection	Resistance
.1 μF		
.01 μF		
100 pF		
10 μF		
40 μF		

3. Open capacitors - there will be no deflection of the meter needle. Care must be taken when checking very small capacitors as the deflection will be very slight.

4. Shorted capacitors - there will be a large deflection of the needle toward zero ohms. The needle will stay there indicating a short circuit path through the dielectric.

5. Leaky capacitors - there will be normal deflection of the needle with some charging, but the needle will settle out at a much lower resistance than normal.

INFORMATION SUMMARY

1. The effect of a capacitor is to build a counter EMF which opposes the flow of alternating current. This opposition is called capacitive reactance and is measured in ohms (Ω). This reactance is mathematically similar to inductive reactance except that it has the opposite polarity.

2. The amount of capacitive reactance can be determined by

$$Xc = \frac{1}{2\pi fc}$$

Xc = capacitive reactance measured in ohms

2π = constant factor 6.28

f = frequency in Hz

c = capacitance measured in farads

To simplify calculations of Xc, you take the constant $\frac{1}{6.28}$ and convert it to .159. The formula

$$Xc = \frac{.159}{fc}$$

is used very often when calculating Xc.

3. This Xc formula brings out two important facts.

   a. As the frequency increases, Xc decreases. This is the reverse of the situation for X_L, which changes directly with frequency.

   b. Xc is inversely proportional to capacitance, which means that as capacitance is **increased**, Xc **decreases**.

The reactance formula can be transposed to find capacitance or frequency.

$$C = \frac{.159}{fXc} \quad \text{or} \quad f = \frac{.159}{CXc}$$

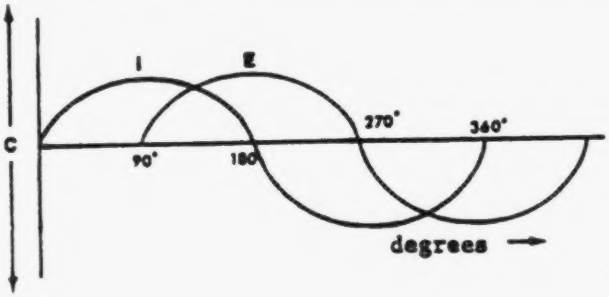
Information Summary, continued

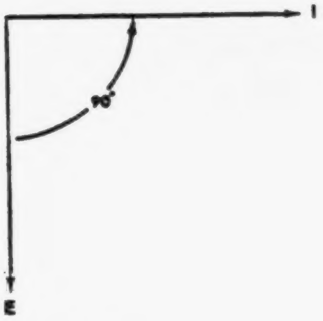
4. When capacitive reactance are connected in series or parallel the values can be combined in the same way as resistances.

For series: $X_{ct} = X_{c1} + X_{c2} + X_{c3}$

For parallel: $X_{ct} = \dfrac{1}{\dfrac{1}{X_{c1}} + \dfrac{1}{X_{c2}} + \dfrac{1}{X_{c3}}}$

5. The phase relationship which exists between current and voltage in a capacitive circuit is exactly the opposite to that of an inductive circuit. In purely capacitive circuit, the current leads the voltage by 90 degrees. The voltage lag is due to the counter EMF of the capacitor. Therefore, the current reaches its peak before the voltage.



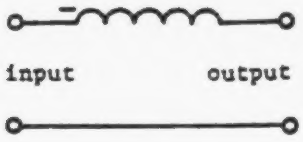


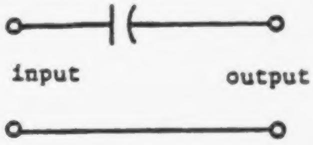
6. Capacitive reactance and current in a capacitive circuit with negligible resistance can be found by using Ohm's Law.

$I = \dfrac{E_c}{X_c}$ or $E_c = IX_c$ or $X_c = \dfrac{E_c}{I}$

Information Summary, continued

7. As you study electrical circuits, it will be very helpful to know some of the comparisons of inductive and capacitive reactances. (See circuit and chart below)





For X_L and X_C the effects, then, are as follows:

X_L	X_C
INCREASES WITH HIGHER FREQUENCY	DECREASES WITH HIGHER FEQUENCY
INCREASES WITH MORE INDUCTANCE	DECREASES WITH MORE CAPACITANCE
ALLOWS D/C TO PASS	BLOCKS D/C
ALLOWS MORE CURRENT AT LOW FREQUENCIES	ALLOWS LESS CURRENT AT LOW FREQUENCIES

EXPERIMENT 8

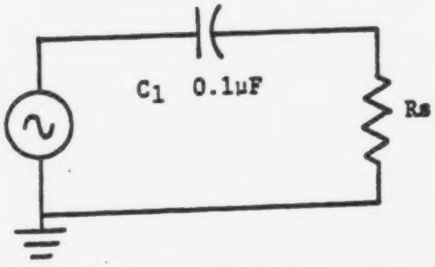
MATERIALS - EQUIPMENT

audio generator
oscilloscope
VTVM
capacitors: 0.01 µf, 0.05 µf, 0.1 µf. 0.5 µf

PURPOSE: To demonstrate the relationship of capacitive reactance to frequency and capacitance.

PROCEDURE:

1. Connect the cirucit as shown.



2. Set the audio generator at 100 Hz to a convenient value, 5 to 10 volts, measured with a VTVM. Maintain this value throughout the experiment.
3. Measure the voltage across the current sampling resistor, V_R, and note the value in Table 1.
4. Adjust the frequency of the generator to 500 Hz and measure V_R.
5. Repeat Step 4 for each value of frequency in Table 1.
6. Calculate the values of current for each frequency and enter in the table:

$$I = \frac{V_R}{R}$$

Experiment 8 (cont'd)

7. Calculate the values of capacitive reactance for each frequency and enter in the table: (Xc meas.)

$$X_C = \frac{V_{gen}}{I}$$

8. Calculate each value of Xc using the formula

$$X_C = \frac{1}{2\pi FC}$$

and enter in the table. (Xc CAL)

9. List any reasons you may have for explaining why these two values of Xc are not the same (see instructor).

10. Answer the following:

  a. As the frequency increases. the Xc ______________________________

  b. As the frequency decreases, the Xc ______________________________

  c. As the frequency decreases, the current __________________________

  d. As the frequency increases, the voltage across the capacitor __________

  ____

11. Set the generator to 1000 Hz and replace the .1 μfd capacitor with a .01 μfd.

12. Measure V_R and enter this value in Table 2.

13. Replace the capacitor with a .05 μfd cap., measure V_R, and enter in the table.

1 . Repeat Step 13 using a .1 and a .5 μfd cap.

15. Calculate I and Xc for each value of capacitance and enter in the table.

16. Calculate Xc for each value of capacitance using

$$Xc = \frac{1}{2\pi FC}$$

and enter in the table under Xc CAL

17. What is the reason for the difference in the two values of Xc? (See instructor).

Experiment 8 (cont'd)

18. What is the relationship between Xc and the size of the capacitor?

19. Answer the following:

    a. As C increases, Xc ______________________________

    b. As C increases, current _________________________

    c. As C decreases, Vc ______________________________

TABLE 1

Freq.	V_R	I	Xc meas	Xc CAL
100 Hz				
500 hz				
1 Khz				
5 Khz				
10 Khz				

C	V_R	I	Xc meas	Xc CAL
.01				
.05				
.1				
.5				

EXPERIMENT #9

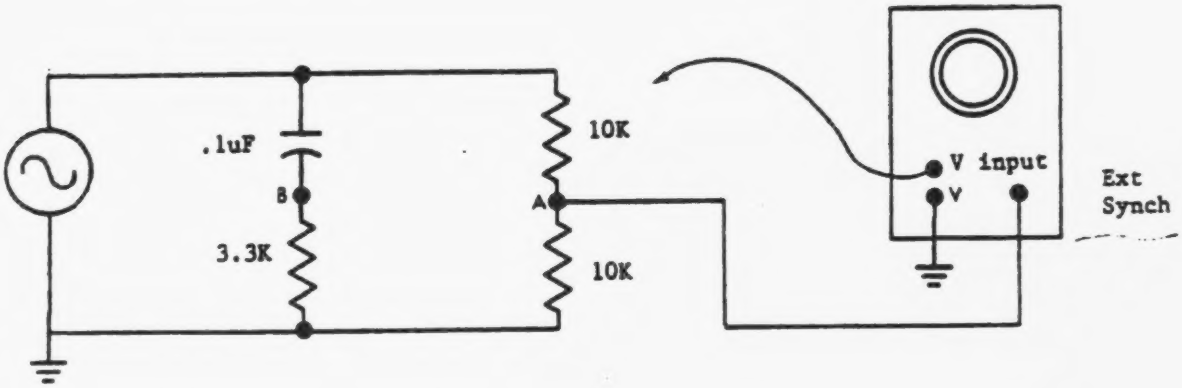
CAPACITIVE PHASE SHIFT

MATERIALS - EQUIPMENT

audio generator
oscilloscope
.1 µfd capacitor
3.3 K resistor
two 10 K resistors

PROCEDURE:

1. Connect circuit as shown below:



2. Adjust AF generator to 200 Hz sine wave (output voltage about 30 VPP)

3. Connect common ground of oscilloscope to circuit marked ground.

4. Connect lead from ext synch of the scope to point A. Set selector switch to ext synch.

Experiment #9 continued

5. Connect the vertical input of the oscilloscope to point A. Adjust scope for two cycles of a sine wave. The wave form should be about 10 VPP. This is a purely resistive circuit. Align the peak of one wave on the center line of the screen.

6. Now move the vertical lead of the scope to point B. But do not adjust the scope. Observe that the peak is no longer on the center line. It has moved a little less than 90 degrees.

7. What caused the sine wave to shift?

8. Should the sine wave have shifted more than 90 degrees?

9. This experiment verifies that a capacitive element can cause a phase shift in voltage.

CAPACITORS AND RC TIME

Lab Sheet #16

OBJECTIVES

To learn how to test capacitors with an ohmmeter.
To design, connect, and test RC Time Constant circuits.
To observe the effects of a short and long RC Time Constant circuit on a square wave.

FORWARD

Because you have had considerable opportunity to use the test equipment in previous Lab Sheets, you now need only a minimum of instruction in setting up Project circuits. Therefore, in this and future Lab Sheets, you will not be reminded of such basic steps as keeping all the common grounds connected together. You are encouraged to operate as your own quality control inspector. If your circuit does not operate as expected, you can do your own troubleshooting. One of the primary duties of an electronics technician is to troubleshoot equipment. You cannot ever get too much practice. Occasionally you may need to seek help from other students or the instructor. However, your best formula for success on the job is to focus on using your own skills and self-sufficiency.

To help you continue expanding your knowledge and skills, periodically throughout this and future Lab Sheets you will see these notations: "F.Y.I." (which means: "For Your Information"). Each "F.Y.I." will be followed by bits of valuable information which will relate to the general information, knowledge, and skills that you can use to become an outstanding electronics technician. However, it may not be a direct part of the Project you are doing at the time.

MATERIALS

Capacitor Board
DMM
VTVM OR VOM
Oscilloscope
3 scope leads
Decade Box
Resistor: 100k

PROJECT 1: Checking Capacitors with an Ohmmeter

INTRODUCTION

Capacitors can be checked with an ohmmeter for (1) opens, (2) shorts, and (3) high resistance leaks at low voltage. Common capacitor faults are these:

OPEN: Does not take a charge, does not store electrons. A good capacitor will show a momentary dip, or low ohms reading, when the ohmmeter is touched to the leads. The smaller the value of the capacitor, the less the dip will be noticed. For accuracy and safety, ALWAYS DISCHARGE the capacitor BEFORE and AFTER testing with an ohmmeter.

SHORT: Zero or low ohms reading due to plates touching inside the capacitor or insulation broken down. Reads 0 to a few kohms. A good capacitor should read infinite resistance after it takes a charge from the ohmmeter.

LEAKY: The insulation between plates has deteriorated or there is dirt along the outside of the case. It may have megohms of resistance. This is common for electrolytic capacitors after years of service or storage. A good capacitor should read infinite resistance after it takes a charge from the ohmmeter.

Although a capacitor may check good with an ohmmeter, it is possible that under a working voltage it may leak (that is, act like a resistor) or break down and short. After the working voltage is removed, it may again check good with an ohmmeter. If you suspect a capacitor to be faulty in equipment on the job, you may have to replace it with a known good capacitor of equal value to test it. However, use discretion in replacing components as a troubleshooting technique. Don't change it unless you know it is bad! Excessive soldering on a printed circuit board can destroy the board. Suspected open capacitors can be easily paralleled with a known good capacitor, using clipleads, as a way to test it.

INSTRUCTIONS

1. Locate and identify these capacitors as indicated.

C1 = .002uF

C2 = .01uF

C3 = .1uF

C4 = .1uF

C5 = .33uF

C6 = 2uF

C7 = 10uF *

C8 = 100uF *

C9 = 100uF *

C10 = 1000uF *

NOTES FOR STEPS 2 AND 3 BELOW:

a. The preceding capacitors marked * are polarized. Negative volts must go to the end marked "-" or with the band. Some may have an arrow pointing to the negative end. Be sure the "-" and "+" leads of the ohmmeter are correctly applied. Incorrectly applied polarity from the ohmmeter can result in an incorrect measurement.

b. Before and after testing a capacitor with an ohmmeter, discharge the capacitor with a cliplead (momentarily placed across it) before going to the next step. Even the several volt charge from the ohmmeter could damage some sensitive components in electronics equipment that you may work on in the future.

c. You will notice that, with the larger capacitor values, the capacitor will appear shorted at first until it becomes charged. It may even take minutes for very large value capacitors (1000uF and up) to charge. To speed up the charging time, temporarily switch the ohmmeter to the R X 1 range. Then, after it is charged, switch back to the highest range (R X 1Meg) to check leakage.

2. Using the VTVM ohmmeter, check all capacitors for (1) charging, (2) shorts, and (3) low voltage leakage. Record your findings below.

Capacitor #	Takes a Charge? (YES/NO)	Shorted? (YES/NO)	Leaking? (YES/NO)(OHMS)
C1	__________	__________	_____ ______ohms
C2	__________	__________	_____ ______ohms
C3	__________	__________	_____ ______ohms
C4	__________	__________	_____ ______ohms
C5	__________	__________	_____ ______ohms
C6	__________	__________	_____ ______ohms
C7	__________	__________	_____ ______ohms
C8	__________	__________	_____ ______ohms
C9	__________	__________	_____ ______ohms
C10	__________	__________	_____ ______ohms

Were any of the capacitors not charging? YES/NO
Were any of the capacitors shorted? YES/NO
Were any of the capacitors leaky at low voltage? YES/NO
(If "YES", advise your instructor.)

3. Using the DMM ohmmeter, check the capacitors again to compare the operation of the DMM with the VTVM. It is important that you be able to reliably check capacitors routinely with any type of meter as an electronics technician.

Capacitor #	Takes a Charge? (YES/NO)	Shorted? (YES/NO)	Leaking? (YES/NO)(OHMS)
C1	________	________	____ ______ohms
C2	________	________	____ ______ohms
C3	________	________	____ ______ohms
C4	________	________	____ ______ohms
C5	________	________	____ ______ohms
C6	________	________	____ ______ohms
C7	________	________	____ ______ohms
C8	________	________	____ ______ohms
C9	________	________	____ ______ohms
C10	________	________	____ ______ohms

Do the DMM readings agree with the VTVM readings in STEP 3? YES/NO

Can you identify a good* capacitor using the VTVM or DMM? YES/NO

(* Well, let's say: "Probably good." This is not a completely reliable check under high voltage conditions.)

SUMMARY

You should have learned how to use an ohmmeter to conduct some of the checks on a capacitor. Evidence of charging, low voltage shorts, and leakage can be identified with an ohmmeter; however, this is not conclusive proof that the capacitor will work in a circuit with higher voltage. Suspected open capacitors in a circuit can be checked by temporarily placing a known good capacitor in parallel, using clip leads. Other suspected shorted or leaking capacitors may have to be replaced by a known good one. Capacitor checking instruments are manufactured but are not as readily available as ohmmeters.

PROJECT 2: RC Time Constants

INTRODUCTION

There is a mathematical relationship between the RESISTANCE and CAPACITANCE in an RC circuit, and the TIME it takes the capacitor to charge to an established value.

R X C = Time Constant

R is in ohms, C is in Farads, and T is the Time (in seconds) to charge to 63% of the applied voltage. The same relationship is true for discharge Time. In other words, in 1 "Time Constant" a capacitor can discharge 63%.

It takes 5 "Time Constants" for a capacitor to be FULLY charged or discharged.

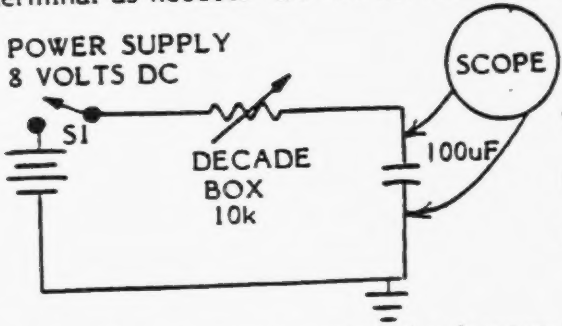
In the following Project you will observe this "Time Constant" phenomena.

MATERIALS

Decade Box

INSTRUCTIONS

1. Connect the circuit below. NOTE: Your red banana plug will be used for switch S1. Just connect and disconnect it from the power supply "+" output terminal as needed. Do not connect it until directed to "close S1" in STEP 2.



SCOPE SETTINGS

VERT.AMP.: 2 V/DIV.

HORZ.AMP.: .5V (fully CCW)

AC/DC Button: DC (out)

2. Set the scope sweep ground reference to the bottom line of scope graticule. Now close S1 and observe C1 charge. (You should see the dot rise to 8 volts in approximately 5 seconds.)

Did it rise to 8 volts? YES/NO

3. Open S1 by unplugging the red banana plug from the power supply. Discharge C1 by touching the red lead to the black lead momentarily.

NOTE: MAKE IT A PRACTICE TO ALWAYS DISCHARGE CAPACITORS AFTER THEY HAVE BEEN CHARGED.

4. Calculate 63% of 8 volts: _______volts. Identify where this voltage will appear on the scope graticule: _______cm.

5. Calculate the time it will take C1 to charge 63% and also to be fully charged.

63% charged: R X C = T ______ seconds.

Fully charged: 5 X T = ______ seconds.

6. Using a watch with seconds indicated, time how long it takes C1 to charge both to 63% and to fully charge after S1 is closed.

63% charged: ______ seconds. Fully charged: ______ seconds.

Was it close to that calculated? YES/NO

7. Calculate the RC Time for each of the resistance values below with C1=100uF:

100kohms X 100uF = ______ sec. 5 X T = ______ sec.

10kohms X 100uF = ______ sec. 5 X T = ______ sec.

1kohms X 100uF = ______ sec. 5 X T = ______ sec.

100ohms X 100uF = ______ sec. 5 X T = ______ sec.

10ohms X 100uF = ______ sec. 5 X T = ______ sec.

8. Using the previous procedure, check the charge time for each of the circuits using the STEP 7 resistances.

Were they all close to the time calculated? YES/NO

NOTE: You may have observed the capacitor discharging when S1 was disconnected from the power supply. This is due to several causes: scope internal resistance, capacitor leaking, dirt, or other material between capacitor leads.

PROJECT 3: Designing and Testing RC Time Circuits

INTRODUCTION

RC Timing circuits are used extensively in electronics equipment. These simple circuits are important to understand. The following Project will give you the opportunity to work some more with RC timing circuits. Experiment with these circuits until you fully understand how the values of resistance and capacitance affect the charge and discharge time.

INSTRUCTIONS

1. Calculate the missing data for each RC Time circuit on the next page. Then connect each circuit and test it. Some of these circuits will have a time constant too short to time, so just observe their fast response.

Circuit #	Resistance	Capacitance	Time	5T
1	500kohms	10uF	______	______
2	20kohms	1000uF	______	______
3	950kohms	2uF	______	______
4	______	1000uF	1 second	______
5	100kohms	______	______	5 sec.
6	*______	______	______	75 sec.
7	______	.01uF	8ms	______
8	______	.33uF	247.58ms	______
9	*______	______	100ns	______
10	450kohms	100uF	______	______

* NOTE: Use any combination to give the desired time.

PROJECT 4: RC Coupling Circuits

INTRODUCTION

RC circuits are used extensively in electronics equipment. One common use is to block D.C. and pass A.C. signals. An example of such an application is in the Tektronix oscilloscope vertical amplifier input circuit shown below. Notice that with the AC/DC switch closed (IN), there is a capacitor placed in the circuit. This capacitor blocks D.C. and passes only A.C. signals to the vertical amplifier. You will now connect a similar circuit and test it to see if it blocks D.C. and passes A.C.

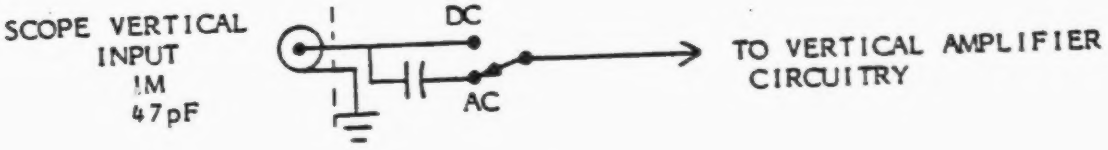


Figure 1

INSTRUCTIONS

1. Connect the RC coupling circuit in Figure 2.

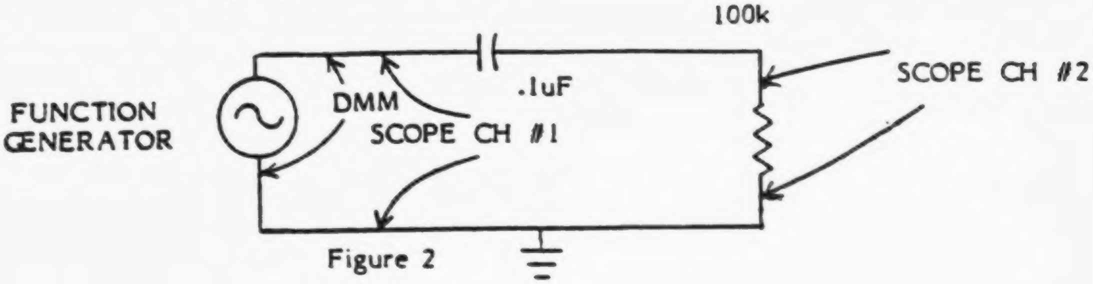


Figure 2

2. Set the DMM for D.C. volts. (NOTE: Both D.C. and A.C. will be coming from the Function Generator. You will be measuring only the D.C. with the DMM.)

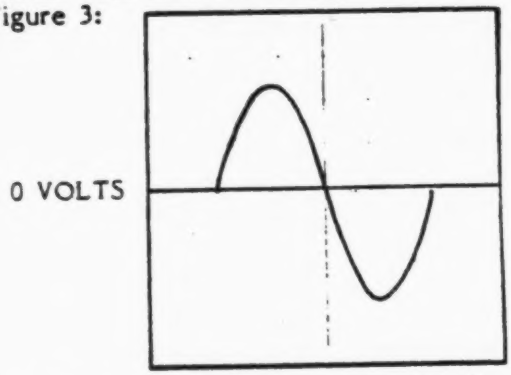
3. Set the Function Generator for a 1kHz, 5 volts (p-p) sine wave using the scope.

4. Locate the "OFFSET" knob on the Function Generator. Turn it clockwise while observing the DMM. Notice that the DMM indicates a D.C. voltage. This D.C. voltage can be varied by the OFFSET knob to both "+" and "-". Set the D.C. OFFSET voltage to approximately 0 volts on the DMM.

5. Set the scope vertical amplifier channels 1 and 2 for"DC"(OUT) and 5 v/div.

6. Set the scope so that the two sine waves are superimposed and are in the center of the graticule. This is the 0 voltage reference level. It should appear similar to Figure 3:

Figure 3

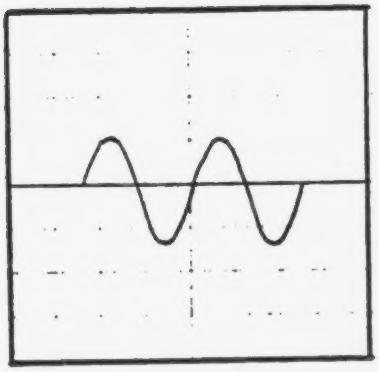


NOTES FOR STEP 7: You will now observe the RC circuit block the D.C. offset voltage from the Function Generator, yet pass the A.C. sine wave.

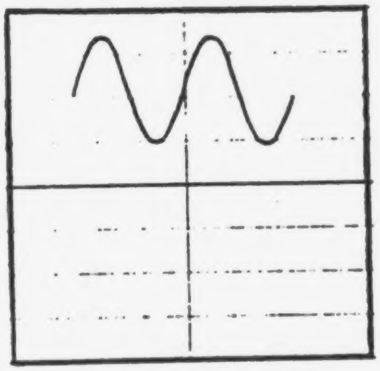
Channel 2 sine wave should remain at 0 voltage reference level after the D.C. offset voltage is changed. (You may see a momentary movement of the channel 2 sine wave due to the capacitor changing its charge level. However, the sine wave should rest at the 0 voltage reference level after the momentary charge takes place.)

Channel 1, which does not have the RC coupling circuit, will show the effects of both the D.C. and the A.C. from the Function Generator. As you change the offset voltage, you should observe the channel 1 sweep move up or down on the scope. Channel 1 moves because the D.C. offset voltage plus the sine wave are both affecting the sweep.

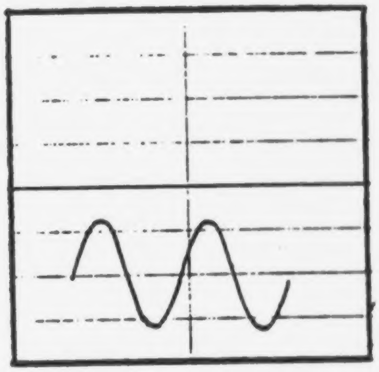
7. While observing the scope, turn the Function Generator OFFSET control. Note the voltage and polarity on the DMM.



A.C. with 0 volts D.C.



A.C. with + volts D.C.



A.C. with - volts D.C.

8. Set scope channel 1 vertical amplifier DC/AC button to A.C.(IN). Repeat the test with the OFFSET knob. Do either scope sweeps indicate a D.C. voltage?

YES/NO (They should not)

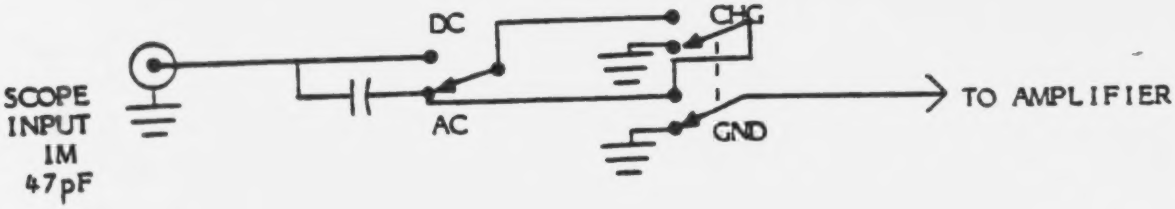
SUMMARY

You should have observed that an RC circuit can be used to block D.C. voltage and still pass the A.C. signal.

You should understand that the DC/AC button on the Tektronix scope vertical amplifier switches a capacitor into the circuit when set for AC(IN). This blocks D.C. voltage from reaching the scope input amplifier but passes the A.C. signal. However, when the amplifier is set for DC(OUT), the capacitor is switched out of the circuit and both D.C. and A.C. reach the scope amplifier. Sometimes a D.C. voltage will deflect the sweep above or below the scope screen so the A.C. signal cannot be seen. Pushing the A.C. button "IN" will block the D.C. so the A.C. signal can be seen on the scope.

F.Y.I.   F.Y.I.   F.Y.I.   F.Y.I.   F.Y.I.   F.Y.I.   F.Y.I.

Here is some information which can be useful for Tektronix or other high quality scopes. Below is shown both the DC/AC switch and the GND (ground) switch on the Tektronix scope vertical amplifiers. Notice that when the ground switch (GND) is "IN", there is a ground placed on the amplifier input stage.



Notice also that the AC/DC button and the GND button are marked "PRE CHG"(pre-charge). When both buttons are pushed in (as shown above), the scope internal capacitor(C1) is charged rapidly to the source voltage being tested. This prevents the capacitor's charging current, when first connecting to a circuit with D.C. voltage on it, from deflecting the sweep off the face of the CRT. This happens on the 1 mv/div and 50 mv/div settings mostly, and causes the scope sweep to disappear off the CRT for a short while until the capacitor(C1) charges. Outlined here is the procedure for using this feature to prevent losing the sweep when working with circuits which have both D.C. and A.C.

1. Push in both buttons before connecting to a circuit with an A.C. signal riding on a D.C. voltage.
2. Connect the scope leads to the circuit and wait one second for the scope internal coupling capacitor(C1) to charge.
3. Release the GND button. Now the display will remain on the screen and the A.C. signal can be measured in the usual manner.

You can use this procedure to good advantage in the future.

PROJECT 5: Long RC Time Constants

INTRODUCTION

In the previous Projects you have learned these things about capacitors:

a. Capacitors can be checked with an ohmmeter for some conditions such as charging ability, shorts, and leakage. These checks are not conclusive, however, that the capacitor will work in a particular circuit.

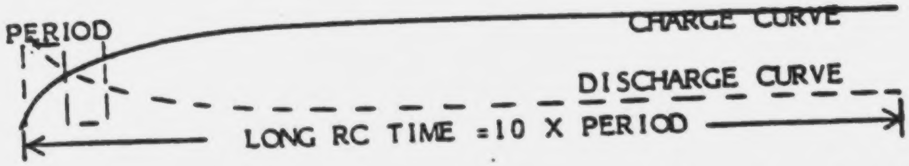
b. Capacitors block D.C. voltage but can pass an A.C. signal.

c. Capacitors take and hold a charge.

d. A resistor in series with a capacitor extends the time for the capacitor to charge. The formula R X C calculates the time (in seconds) for the capacitor to charge 63% of the applied charging voltage. This is called " 1 Time Constant".

e. A capacitor requires 5 Time Constants to fully charge.

You will now experiment with RC circuits where R X C is at least 10 times the duration of the PERIOD of a signal. This is called a "long RC time constant circuit". You should observe that, for minimum distortion of an A.C. signal, long RC time constant circuits should be used. This means that the value of the capacitor and resistor used in a coupling circuit must have a mathematical product of 10 times the period of the frequency to be passed.



This principle is important in high fidelity amplifiers where the signal is passed from one stage to the next through an RC coupling circuit. As the components age, the values may change so that the circuit no longer is a long RC time circuit for the lowest frequencies. This will result in poorly sounding low frequencies and distorted pulsed wave shapes. Unless the circuit has a long RC Time, square waves will be distorted and sine waves will have excessive phase shift.

In the following Project you will experiment with this principle.

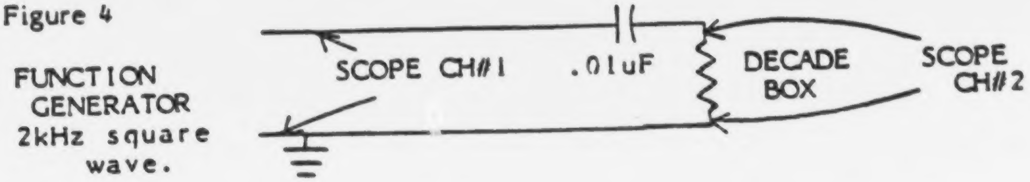
INSTRUCTIONS

1. Calculate the PERIOD for a 2kHz signal. PERIOD:________ms.

2. Now multiply the PERIOD by 10: __________ms. Observe in Figure 4 the relationship of a 2kHz square wave to the charge and discharge curves of a Long RC Time circuit.

3. Connect the circuit below. You will calculate the value for R1 in STEP 4.

Figure 4



4. Calculate the value of R1 in order to have a Long RC Time for 2kHz:

   a. The period of a 2kHz signal is _________ milliseconds.

   b. Ten times the period of a 2kHz signal is _______milliseconds.

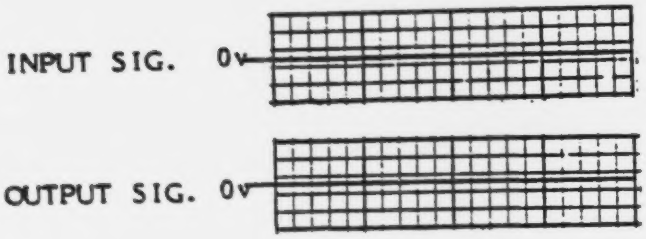
   c. Calculate R1 this way:

$$R1 = \frac{10 \text{ X (Period)}}{.01\text{uF}}$$

R1 value for a Long RC Time circuit:_________ohms.

5. Set the Decade Box to R1 value calculated in STEP 4 to make a Long RC Time circuit for 2kHz.

6. Using the Function Generator, apply a square wave 4v p-p signal at 2kHz. Compare the input signal (channel 1) to the output signal (channel 2). You should observe that they are close to the same SHAPE with little distortion. Disregard the VOLTAGE of the output since this is a voltage divider. We are interested in only the shape of the output signal from this Long RC Time circuit. Draw two cycles of both the input signal and the output signal below.



7. While observing the shape of the signals on the scope, change R1 value to both higher and lower values. Note the shape of the output square wave change.

NOTE: The input may also change, due to the loading effect on the Function Generator as the capacitor charges, when the resistance is exceptionally low. There isn't much you can do except observe that this is a problem when the resistance is low.

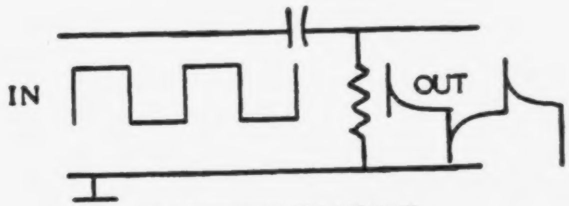
SUMMARY

For minimum distortion of a square wave passing through an RC coupling circuit, the RC Time must be "Long". A "Long RC Time circuit" is one where R X C = 10 times the period of the lowest frequency passing through it.
NOTE: Some texts only briefly mention Long RC Time circuits and describe them differently than above. Some authors use a factor of 5X for a Long RC Time cirucit. However, for our work we will use the "10X" definition for a Long RC Time circuit. You should see that there is much less distortion.

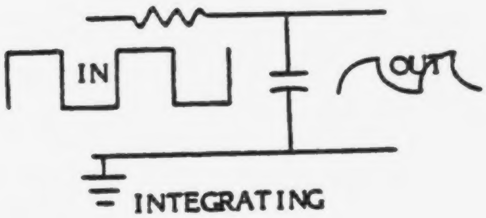
PROJECT 6: Short RC Time Constant Circuits

INTRODUCTION

A Short RC Time Constant circuit is one where R X C = 1/10 of the period of the signal frequency. Short RC Time circuits distort square waves greatly. However, this can be used to good advantage to form new types of waveshapes. Below are two variations of Short RC Time Constant circuits. The one on the left is called a DIFFERENTIATING circuit. The circuit on the right is an INTEGRATING circuit.



DIFFERENTIATING



INTEGRATING

In this Project you should observe how short RC Time constant circuits distort certain types of waves to make new, more usefully shaped waves.

INSTRUCTIONS

1. Calculate a SHORT RC TIME for 10kHz:

   a. Period of a 10kHz signal:________microseconds.

   b. One-tenth the period of a 10kHz signal:_______microseconds.

   c. Calculate R1 this way:

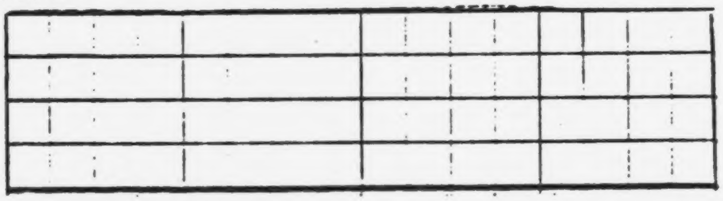
$$R1 = \frac{.1 \times (\text{Period})}{.01uF}$$

R1 value for a Short RC Time circuit:__________ohms.

2. Set the decade box to the value calculated for a Short RC Time circuit and observe the output signal shape. Set the scope so you can see at least 5 cycles.

You should be observing a differentiated wave shape. This wave is often used as a trigger pulse for timing circuits. Notice that you have both positive and negative pulses. Vary the Function Generator FREQUENCY and notice the TIME between pulses change.

3. Draw the differentiated wave shape below and in relation to time of the input square wave.



DIFFERENTIATED WAVE

4. Just to experiment, set the Function Generator so you have negative timing pulses on the scope every 3.5ms. Calculate the frequency: _______Hz. Try 4.75ms positive pulses. Calculate the frequency: _______Hz.

NOTE: WHEN USING THE FREQUENCY COUNTER TO MEASURE FREQUENCY, IT WILL MEASURE INACCURATELY IF THE WAVE IS DISTORTED. THEREFORE, MOMENTARILY SWITCH THE FUNCTION GENERATOR TO SINE WAVE OUTPUT WHEN MEASURING FREQUENCY IN THE NEXT STEP.

5. Measure the frequency of the signals in STEP 4 and compare your calculations.

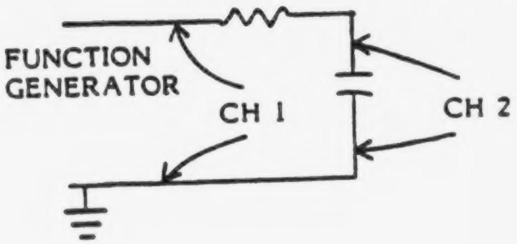
How did you do? Close Off by a factor of 2 Blew it

6. Switch the Function Generator to a TRIANGLE wave output. Experiment with the function Generator Frequency and amplitude controls. You should be able to see the output triangle wave distorted into a square wave at some frequency!

7. Reconnect the circuit as shown below to make a Short RC Time Integrating circuit.

DRAW INPUT

DRAW OUTPUT



8. Experiment with this circuit. You should find that a square wave is distorted into a triangle wave. If you feed a differentiated wave into this circuit you will get a square wave output!

Passing a sine wave through a differentiating or integrating circuit results only in a change in phase; the output waveshape remains a sine wave.

SUMMARY

You should have observed that an RC coupling circuit can block D.C. while passing the A.C. signal.

You should have observed that, for minimum distortion of a signal, an RC coupling circuit should have a Long RC Time Constant for the lowest frequency present. This is particularly important in audio amplifiers for best fidelity.

You should have observed the effects of passing a square wave through both a differentiating and an integrating Short RC Time constant circuit. Although the wave shape is distorted, it can be used for new applications. One of these applications is for both positive and negative trigger pulses in timing circuits.

PROJECT 7: Self Evaluation Quiz

INSTRUCTIONS

Cross out all incorrect words to make the statement correct.

1. Generally there are (three) (five) (seven) main things that you can check for in a capacitor when using an ohmmeter.

2. An ohmmeter (can) (cannot) check for high voltage breakdown in a capacitor.

3. An ohmmeter can check a capacitor for (capacitance) (capacitive reactance) (low voltage leakage) (short) (open) (working voltage leakage) (termites).

4. A Long RC Time constant circuit will pass a square wave causing (very little) (much) distortion.

5. A square wave into a Short RC Time constant circuit will be distorted (very little) (greatly).

6. Across the resistor, in a Short RC Time constant circuit, there appears a/an (differentiated) (integrated) wave. Across the capacitor there appears a/an (differentiated) (integrated) wave.

7. If a small A.C. signal is deflected off the scope, you should try to view it by pushing the (AUTO TRIG) (AC/DC) (DISPLAY) (GND) button IN.

8. For best low frequency response in a HI FI amplifier, using RC coupling circuits, the coupling capacitor value probably will be (small) (large).

9. Capacitors can block (A.C.) (D.C.) (sine waves) (square waves).

10. To most accurately observe low frequency square waves on the scope, the AC/DC switch should be set on (A.C.) (D.C.) (SQ WV).

11. Some capacitors have a band around one end. This indicates the end where (the ohmmeter "+" lead) (all "-" voltages) (all "+" voltages) (no voltages) is/are connected.

12. An arrow on a capacitor indicates (the flow of electrons) (the end that blows off when you connect it incorrectly) (the negative end).

13. (Some) (All) capacitors are polarized.

14. Capacitors should be discharged (only when the instructor is watching) (only after checking with an ohmmeter) (only before checking with an ohmmeter) (only on Fridays) (before and after doing anything with or to them).

15. Capacitors can be used in (timing circuits) (coupling circuits which block D.C. yet pass A.C.) (coupling circuits which block A.C. yet pass D.C.).

Answers to PROJECT 7: Self Evaluation Quiz

1. Three
2. cannot
3. low voltage leakage, short, open.
4. very little.
5. greatly.
6. differentiated, integrated
7. AC/DC
8. large.
9. D.C.
10. D.C.
11. all "-" voltages
12. the negative end.
13. Some
14. before and after doing anything with or to them.
15. timing circuits; coupling circuits which block D.C. yet pass A.C..

Your number correct:____________

How did you do? Fantastic. O.K. All biorhythms must be down today.

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8. large.
9. D.C.
10. D.C.
11. all "-" voltages
12. the negative end.
13. Some
14. before and after doing anything with or to them.
15. timing circuits; coupling circuits which block D.C. yet pass A.C..

Your number correct:____________

How did you do? Fantastic. O.K. All biorhythms must be down today.

Lab. Capacitors in Series & Parallel
Effects on Time Constants and D.C. Voltages

Prob. #1

Solve for: TC, 5TC, E_r, I_r, E_c, I_c

Draw Curves for E_r, I_r, E_c, I_c.

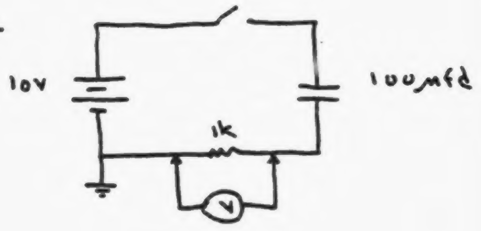

10V
100mfd
1k
V

Fig 1

Prob #2

Solve for TC, 5TC,

Calculate / Measure - Draw Curves

	Calc.	Meas.
V_{c_1}	______	______
V_{c_2}	______	______

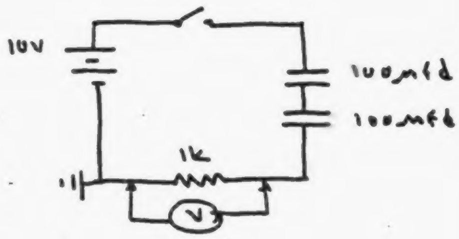

10V
100mfd
100mfd
1k
V

Fig 2

Prob. #3

Solve for TC, 5TC

Calculate / Measure - Draw Curves

	Calc.	Meas.
V_{c_1}	______	______
V_{c_2}	______	______

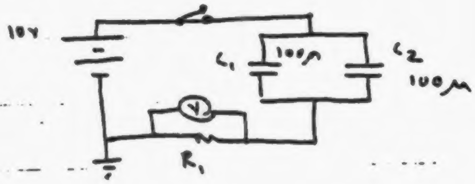

10V
C1
100μ
C2
100μ
V
R1

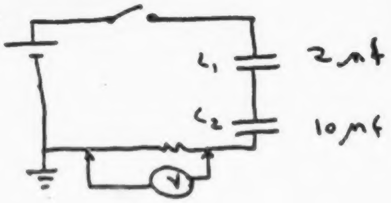
Fig. 3

Prob. #4

Solve for TC, 5TC

Calculate / Measure - Draw Curves

	Calc.	Meas.
V_{c_1}	______	______
V_{c_2}	______	______


C1
2mf
C2
10mf
V

Lab. Report # ______

Draw circuit, List data neatly, Draw curves for the charge times of the circuits.

Write one conclusion for each problem.

CAPACITORS AND CAPACITIVE REACTANCE

Lab Sheet #17

OBJECTIVES

To graph how capacitive reactance changes with frequency
To measure the change in capacitive reactance as capacitance changes
To find the capacitance of an unknown capacitor

MATERIALS

Oscilloscope
Function Generator
Capacitor Board
Resistors: 1k and 2k

PROJECT 1: Capacitive Reactance

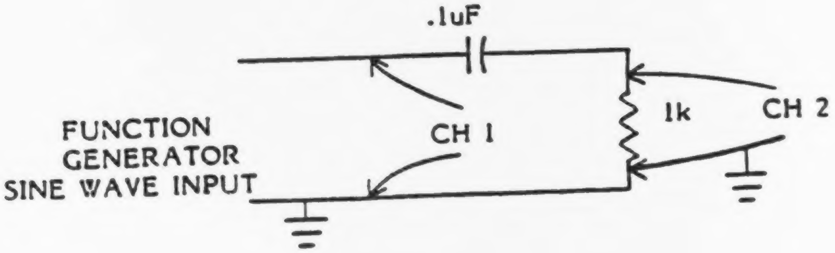
INTRODUCTION

In the previous Lab Sheet you observed many of the capacitor's characteristics. In this Lab Sheet you will explore some more important characteristics of the capacitor.

Capacitive reactance (X_c) is controlled by two factors: (1) the frequency of the current (and voltage), and (2) the amount of capacitance. In this Project you should observe how a change in frequency results in a change in current through an RC circuit. You will be applying different frequencies to capacitors and observe the change in capacitive reactance. Also, you will plot a graph of capacitive reactance versus frequency.

INSTRUCTIONS

1. Connect the circuit below. Measure and record value of R1:______ohms.



2. Calculate the capacitive reactance (X_C) for a .1uF capacitor at each frequency in TABLE 1. Record in X_C column.

$$X_C = \frac{1}{2\pi F C}$$

TABLE 1

Frequency (Hz)	X_C (ohms)	Z (ohms)	Itotal (mA)
1k			
500			
100			
50			

3. Calculate the Impedance (Z) for each frequency in TABLE 1 and then record under the "Z" column.

$$Z = \sqrt{R^2 + X_C^2}$$

4. Calculate Itotal for each frequency. Record under the "Itotal" column in TABLE 1. NOTE: You may use any applied voltage you desire.

$$\text{Itotal} = \frac{\text{Eapplied (rms)}}{Z}$$

5. You must now measure the Itotal in the circuit for each frequency indicated in TABLE 1. To measure Itotal, do this:

a. Apply the frequency indicated in TABLE 1. Be sure to keep the applied voltage the same for each frequency.

b. Measure the voltage drop across R1. Calculate the current and record in TABLE 2 under "Itotal" column.

$$\text{Itotal} = \frac{\text{R1 volts}}{\text{R1}}$$

6. Determine the actual impedance (Z) of the circuit at each frequency. Record under the "Z" column in TABLE 2.

$$Z = \frac{\text{Eapplied(rms)}}{\text{Itotal (As determined in STEP 5, this Project.)}}$$

7. Determine the actual capacitive reactance (X_c) for each frequency in TABLE 2, and record under "X_c" column.

$X_c = \sqrt{Z^2 - R^2}$ From this formula: $Z = \sqrt{R^2 + X_c^2}$

TABLE 2

Frequency (Hz)	X_C (ohms)	Z (ohms)	Itotal (mA)
1k			
500			
100			
50			

8. Plot X_c versus frequency on the attached graph paper (Attachment #1).

9. Does your graph show the X_c decreasing as frequency increases?

YES/NO

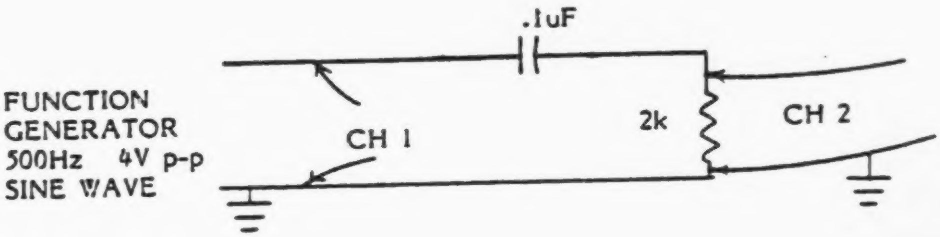
PROJECT 2: Capacitors in Parallel and Series

INTRODUCTION

In this Project you will connect capacitors in parallel, and then in series, to observe how they react to different frequencies.

INSTRUCTIONS

1. Connect the circuit below. Measure and record R1 value:________ohms.



2. Apply a 500Hz, 4 volts p-p sine wave to the circuit. Measure R1volts and calculate Itotal in circuit:

R1volts:______ Itotal:________mA

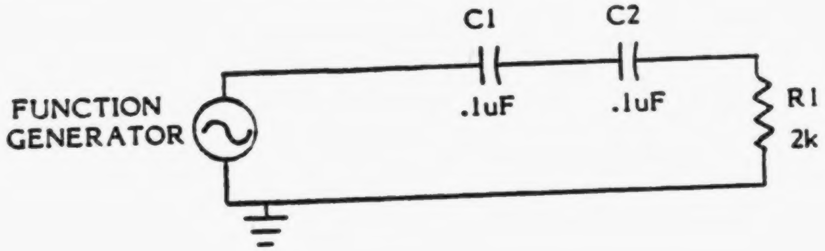
3. Connect another .1uF capacitor in parallel with C1. Measure R1volts again and determine Itotal as done in STEP 2:

R1volts:______ Itotal:________mA

4. Using the data in STEPS 2 and 3, calculate the following. (Show your formulas used. Record answers below.):

	C1	Parallel C1 + C2
Circuit impedance(Zckt):	________	________
Total capacitive reactance (X_c):	________	________
Total capacitance:	________	________

5. Now connect the circuit so that C1 and C2 are in SERIES with each other and R1. Apply the same signal amplitude and frequency.



6. Determine the below data as previously done.

	C1	Series C1 + C2
Circuit impedance(Zckt):	________	________
Total capacitive reactance (X_c):	________	________
Total capacitance:	________	________

7. Did the parallel circuit have less impedance than the series circuit?

YES/NO

Did the parallel have less capacitive reactance than the series circuit?

YES/NO

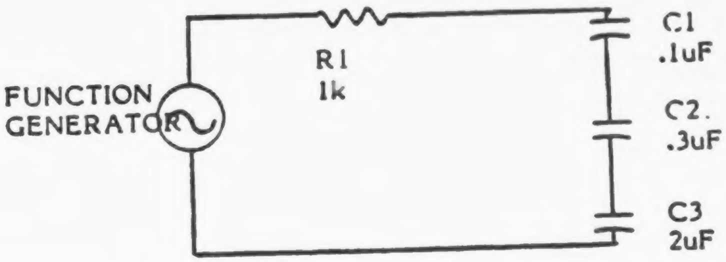
PROJECT 3: Capacitor Voltage Dividers

INTRODUCTION

In this Project you will make a voltage divider with 3 capacitors and observe how they function as A.C. voltage dividers. You should see that they function as A.C. voltage dividers similarly to resistors with D.C..

INSTRUCTIONS

1. Connect the circuit below. (NOTE: "C1", "C2", and "C3" are used to designate the capacitors only on this schematic.)



2. Assume that 8 volts peak-to-peak is applied. Calculate the voltage drops across each capacitor at 500 Hz and then at 5kHz. Show your calculations and formulas below. (You will measure and record the voltage in STEP 3.)

	Volts at 500Hz. (calculated) / (measured)	Volts at 5kHz. (calculated) / (measured)
C1	______________________	______________________
C2	______________________	______________________
C3	______________________	______________________

3. Apply 500Hz, 8 volts p-p to the circuit and measure the voltage across each capacitor. Then apply 5kHz, 8 volts p-p, and repeat the measurements. Record in STEP 2 next to your calculated values.

Are the calculated values close to the measured values? YES/NO

SUMMARY

You should have observed these things about the capacitors in the RC circuits above:

a. Capacitors pass high frequencies more easily than low frequencies.

b. Connecting capacitors in PARALLEL DECREASES the circuit IMPEDANCE.

c. Connecting capacitors in SERIES INCREASES the circuit IMPEDANCE.

d. Capacitors can function as A.C. voltage dividers. The highest voltage drop occurs across the smallest value capacitor.

e. Current in an RC circuit is determined by the circuit impedance. The circuit impedance is the vector sum of the resistance and capacitive reactance (X_c).

PROJECT 4: Finding the Capacitance of an Unknown Capacitor

INTRODUCTION

In a previous Lab Sheet you practiced finding the inductance of an unknown inductor using several methods.

The first method used the voltage divider principle. You set the Decade Box (or a potentiometer) to a value so the voltage across the Decade Box equalled the voltage across the inductance. R then equalled X_L. After finding X_L you found L from this formula: $X_L = 2\pi FL$.

A variation on the first method uses a fixed value resistor. The FREQUENCY is then varied until L1volts equals R1volts. With a known frequency and X_L, the inductance is then found with the formula $X_L = 2\pi FL$.

Another method used the trigonometry formulas:

$$\frac{\text{L1volts}}{\text{R1volts}} = \text{TAN } 0 \qquad \text{and} \qquad \text{TAN } 0 \times R = X_L$$

With this latter method you did not need to make the voltages equal. However, you did need to select a frequency which produced a reasonable phase shift angle. Best accuracy is achieved when the angle is between 30 and 60 degrees.

There are several other methods for finding the inductance of an unknown inductor using other trigonometric formulas. All the methods introduced to you for finding inductance will work also for capacitance. Now you have many tools with which to work on both inductance and capacitance problems. In this Project you will be expected to apply these methods to find the capacitance of an unknown capacitor. You will be given minimum instructions and you are expected to do your work with minimum help from the instructor. This is an excellent opportunity to prove to yourself how much you really do know and how well you can do this very technical type of work.

INSTRUCTIONS

1. Set up a circuit to find the capacitance of an unknown capacitor. You can use any method you like and any equipment (except a Capacitance Meter!). Use the capacitors on the Capacitor Board to practice. Do not use the electrolytic type because they may leak and be out of tolerance. After practicing with the capacitors on the Capacitor Board, obtain a "Practice Test Capacitor" and find the value of it. You should be able to find the capacitance of an unknown capacitor in 20 minutes or less.

2. Can you find the capacitance of an unknown capacitor in 20 minutes?

YES/NO

PROJECT 7: Self Evaluation Quiz

INSTRUCTIONS

Cross out all incorrect words to make the statement correct. (The answers are at the end of the quiz.)

1. The current in a series RC circuit will (decrease) (increase) if a larger value capacitor is installed in place of the original and the frequency remains the same.

2. In a series capacitor voltage divider, most voltage drop appears across the (smallest) (largest) value capacitor.

3. In a series RC circuit the frequency is lowered. To measure the same voltage across the resistor would require that a (smaller) (larger) value capacitor be installed.

4. In a series RC circuit, the current is (different) (the same) in each component.

5. In a series RC circuit, the voltage drop across each component is (different) (the same) (unimportant).

6. The total of all voltage drops in a series RC circuit can be found by (simple addition) (complex addition) (phasor or vector addition).

7. The current in a series RC circuit is limited entirely by (resistance) (capacitance) (impedance) (state law).

8. Impedance in an RC circuit can be calculated using (phasor or vector addition) (an ohmmeter) (a count of resistor bands and multiplying by 1.414).

9. Assume that you have the capacitor voltage divider from PROJECT 3 connected to 8 volts (rms), 60 Hz. The highest voltage would appear across (R1) (C1) (C2) (C3).

10. Refer to the circuit in question 9. The lowest voltage would appear across (R1) (C1) (C2) (C3).

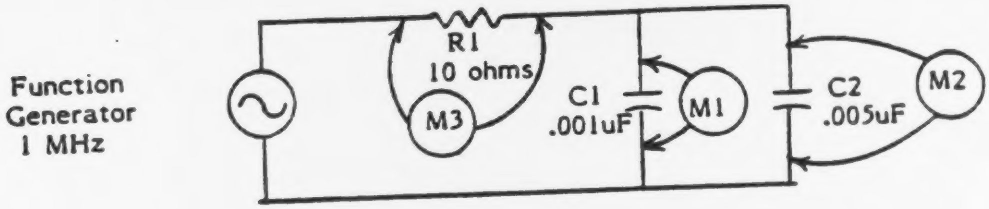
11. Refer to the circuit in question 9. Which component would have approximately 2 volts (rms) across it? (R1) (C1) (C2) (C3)

12. Assume that the voltage divider circuit in PROJECT 3 were connected to 10 volts D.C.. Which capacitor would have the highest charge? (C1) (C2) (C3)

13. Refer to question #12. Which capacitor will have the most electrons stored? (C1 because it is the smallest.) (C3 because it is the largest.) (All capacitors will have the same number of electrons because this is a series circuit.) (None, because capacitors cannot pass D.C..) (C2 because it is in the middle where - meets +.)

14. In a series RC circuit with D.C. applied, most voltage is across the (resistor) (capacitor) when the power is first applied.

Refer to the schematic below for questions 15 through 20.



15. Which component is passing the most current? (R1) (C1) (C2)

16. Which component is passing the least current? (R1) (C1) (C2)

17. Which meter will show the lowest voltage? (M1) (M2) (M3)

18. In the circuit above, if C2 were removed, there would be a decrease in (M1) (M2) (M3) (impedance).

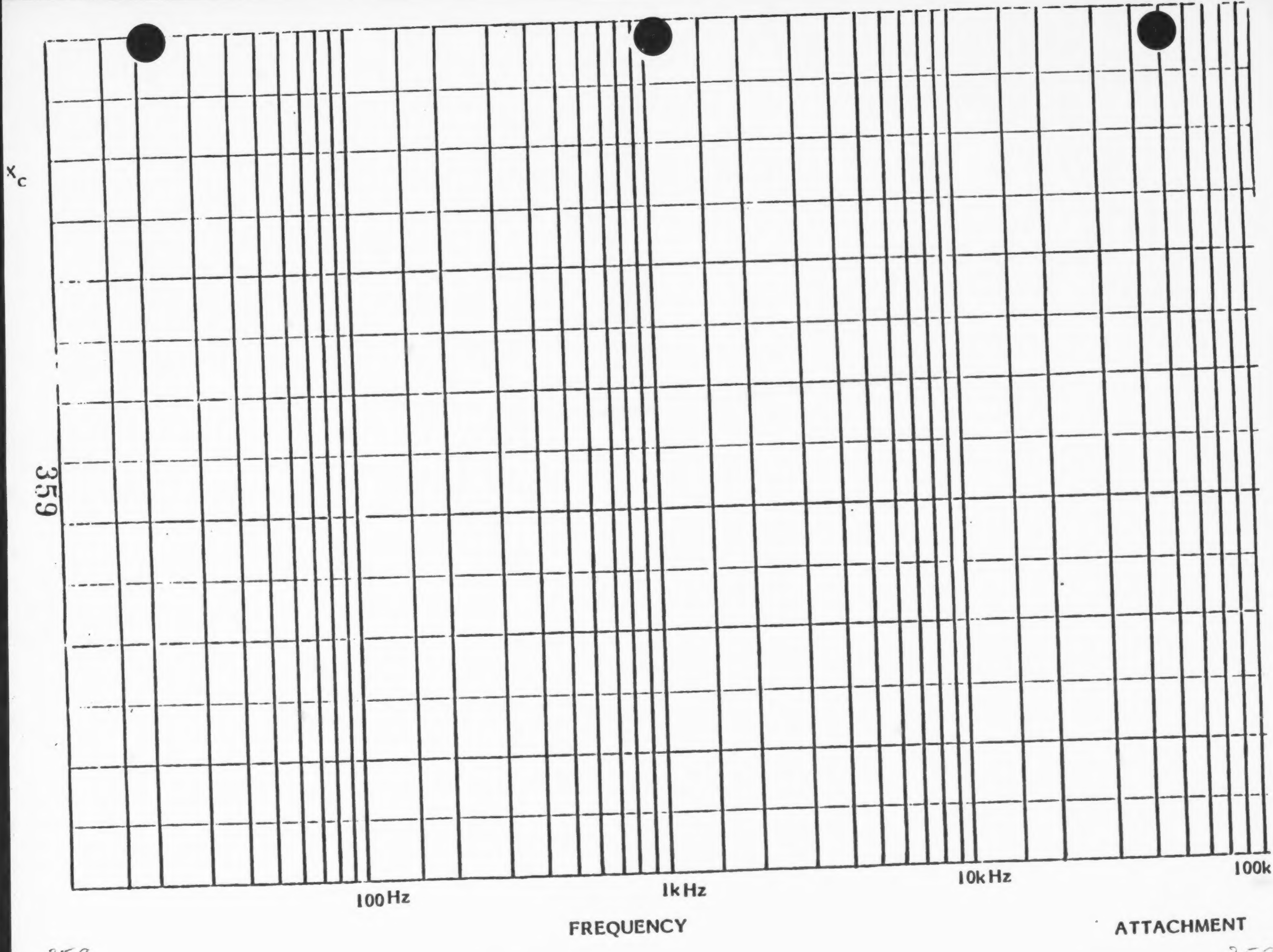
19. If you add a .002uF capacitor in series with the circuit drawn above, you will cause an increase in (current) (M1 voltage) (M2 voltage) (impedance) (resistance).

20. Lowering the frequency to the circuit drawn above will cause a decrease in (M1) (M2) (M3) (impedance).

Answers to PROJECT 5: Self Evaluation Quiz

1. increase
2. smallest
3. larger
4. the same
5. different (usually)
6. phasor or vector addition
7. impedance
8. phasor or vector addition
9. C1
10. R1
11. C2
12. C1
13. all will have the same because this is a series circuit
14. resistor
15. R1
16. C1
17. M3
18. M3
19. impedance
20. M3

Your score: __________ How did you do? Wonderfully! Not badly. *%$#&@!!!



359

ATTACHMENT

359

#1 359A

NAME ________________________

DATE __________ PER. ________

QUIZ: IDENTIFY the UNKNOWN CAPACITOR

DIRECTIONS: OBTAIN CAPACITOR FROM INSTRUCTOR

A. DRAW CIRCUIT - Label ALL VALUES

B. DRAW VECTOR DIAGRAM - Label all values

C. Solve for C_1 - LIST EACH STEP;

- Show all formulae
- Show all Values in formulae
- Indicate "C" in the Last step.

A. CIRCUIT

B. VECTOR DIAGRAM

C. Solve for "C"

STEP

1.

2.

3.

4.

5.

6.

ANSWER $C_1 =$

Self Test

Directions

1. Write the physical definition of a capacitor: ____________________

____

____

2. The charge in a capacitor is stored in the:

   a. plates
   b. leads
   c. dielectric

3. The unit of measure of capacitance is the:

   a. farad
   b. coulomb
   c. voltage
   d. henry

4. If the plate area of a capacitor is increased, its capacitance:

   a. increases
   b. decreases
   c. stays the same

5. If the dielectric thickness of a capacitor is increased, its capacitance:

   a. increases
   b. decreases
   c. stays the same

6. The initial charging current of a capacitor is:

   a. large
   b. small
   c. constant

Self Test continued.

7. Which of the following capacitors will probably be the largest in physical size?

   a. .001 ceramic disk
   b. .001 ceramic tubular
   c. .001 mica
   d. .001 paper

8. Which of the following types of capacitors will have the largest capacitance?

   a. ceramic
   b. electrolytic
   c. air
   d. mica

9. What is the working voltage of three 50 V capacitors of the same size when placed in series?

10. What is the total capacitance of a .01, .02, and .05 μF capacitors placed in parallel?

11. What is the total capacitance of three 30 μF capacitors placed in series?

12. What is the total capacitance of a .02, .06, and .12 μF capacitors placed in series?

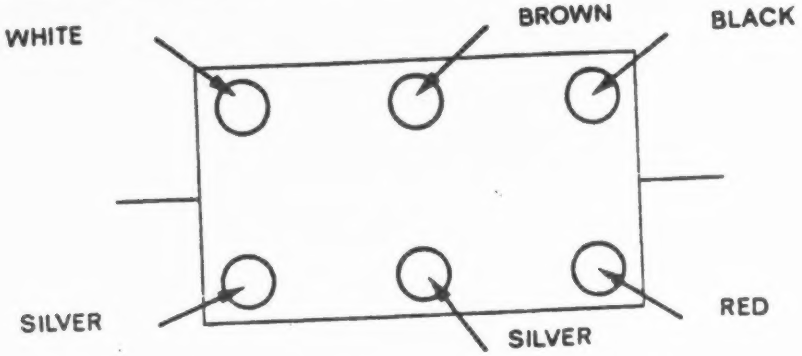
Self Test continued.

13. What is the working voltage of two 50 V and a 25 V capacitor placed in parallel?

14. If a capacitor is being checked with an ohmmeter and there is no deflection of the needle when the test leads are applied, the capacitor is probably:

    a. shorted
    b. leaking
    c. open

15. What is the capacitance of a capacitor color coded as follows?



16. What is the tolerance of the capacitor in question 15?

17. Draw the symbol for a fixed capacitor.

18. The negative plate of a charged capacitor has:

    a. an excess of electrons
    b. a deficiency of electrons

Self Test continued.

19. Draw a diagram showing the least number of 200 V 4 µF capacitors needed for a combination rated at 600 V with 4 µF total capacitance.

20. Given two identical capacitors, one is charged to 200 V and connected across the uncharged capacitor. What will the voltage be on both capacitors?

UNIT EXAM

CAPACITANCE

IMPRORTANT

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question. There is only one correct answer for each question.

1. An AM radio receiver can be tuned with a variable capacitor. (T - F)

2. In the past, capacitors were called or referred to as condors. (T - F)

3. A variable capacitor consists of stationary plates called stator plates and rotating plates called rotor plates. (T - F)

4. Air separates the plates within a cica capacitor. (T - F)

5. In a capacitor, the conducting surfaces are called the dielectrics and the insulating material is called the plate. (T - F)

6. A capacitor is an energy source, the operation of which is similar to that of a voltaic cell. (T - F)

7. One microfarad is equal to one-millionth of a farad. (T - F)

8. One microfarad is equal to one-millionth of a microfarad. (T - F)

9. As a general rule, all capacitors having a capacitance of more than one microfarad are electrolytic capacitors. (T - F)

10. The charging time period of a capacitor can be decreased by the addition of a large value of resistance in series with the capacitor. (T - F)

11. Total capacitance is increased by connecting capacitors in series. (T - F)

12. Capacitive reactance is measured in terms of the basic unit ohms. (T - F)

13. It can be said that a capacitor blocks AC but passes DC. (T - F)

14. Increasing the plate area of a capacitor increases its capacitance. (T - F)

15. A potentially dangerous voltage may exist across some capacitors for many hours after their circuits have been turned off. (T - F)

16. A capacitor can, but seldom does, become open. (T - F)

17. Increasing the spacing between the plates of a capacitor increases its capacitance. (T - F)

18. All capacitors that are in good condition will have a relatively low resistance between their plates. (T - F)

19. The letter symbol for capacitive reactance is "RC". (T - F)

20. The time required for the voltage across a capacitor to reach 63.2 percent of the applied voltage is known as the time constant of the capacitor circuit. (T - F)

21. A capacitor is composed of:
    a. two or more metal plates separated by a dielectric.
    b. one metal plate and one layer of insulation
    c. one plate and one conductor
    d. two plates separated by a conductor

22. While a capacitor is discharging:
    a. the amount of charge stored on the plates increases
    b. the voltage across it is decreasing
    c the voltage across it is increasing
    d. electrons are building up on the negative plate

23. The unit of capacitance is:
    a. ohm b. volt c. farad d. none of the above

24. The term DIELECTRIC STRENGTH means:
    a. the ability of an insulator to withstand electric stress across it without breaking down.
    b. the ability of a conductor to store large voltage values
    c. the ability of a conductor to handle high voltages
    d. none of the above

25. In a parallel circuit, if C_1 = 10uF and C_2 = 2uF, the total capacitance would be:
a. 2µF b. 8µF c. 12µF d. .088µF

26. A .022uF capacitor is connected in series with a .066uF capacitor. The total capacitance is:
a. .088 pF b. .0165µF c. 60.6µF d. .088µF

27. The term in phase indicates that the:
a. current lags the voltage
b. current leads the voltage
c. current and voltage reach given values simultaneously
d. voltage is always higher than the current

28. The formula for capacitive reactance is:
a. __ = 0/E b. X_C = 1/6.28FC c. X_R = 6.28FL
d. $X_{eff} = X_1 = X_C$

29. Alternating current can flow in a capactive circuit with AC voltage applied because:
a. of the high peak value
b. varying voltage produces charge and discharge current
c. charging current flows when the voltage decreases
d. discharge current flows when the voltage increases

30. With higher frequencies, the amount of capacitive reactance:
a. increases
b. stays the same
c. decreases
d. increases only when the voltage increases

31, At a given frequency, substituting a larger capacitance results in:
a. more reactance
b. the same reactance
c. less reactance
d. less reactance if the voltage amplitude decreases

32. The capacitive reactance of a 0.1u F capacitor at 1,000Hz equals:
a. 1,000 ohms
b. 1,600 ohms
c. 2,000 ohms
d. 1,590 ohms

33. The type of capacitor which may be damaged if the applied voltage reverses polarity is the:
a. electrolytic capacitor b. ceramic capacitor
c. mica capacitor d. paper capacitor

34. If a capacitor only circuit has an applied voltage of 100 AC volts a capacitive reactance of 500 ohms, the circuit current is:
a. 5 amps   b. 4 amps   c. 2 amps   d. .2 amps

35. If a short circuit occurs when a breakdown voltage is applied to a capacitor, but the capacitor returns to normal operating conditions when the voltage overload is removed, the capacitor is said to be:
a. in need of replacement
b. off tolerance
c. self-healing
d. variable

36. It is found that a capacitor, when charged, loses its charge in a few minutes. This is most likely owing to:
a. leakage across the dielectric
b. leakage within the anodo
c. leakage within the cathode
d leakage through the surrounding air

37. The capacitive reactance of a 0.01 farad capacitor at 159Hz is:
a. 0.1 farad   b. 0.1 ohm   c. 0.01 ohms   d. 159 ohms

38. The current flow in a capacitive circuit ______________ the voltage by ______________.
a. lags, 45°   b. lags, 90°   c. leads, 0°   d. leads, 90°

39. What is the reactance of a .05 mfd capacitor at 400Hz?
a. 7960 ohms   b. 15920 ohms   c. 31840 ohms   d. 63680 ohms

40. What is the equation for finding the total capacitance of a circuit with four parallel capacitors?

a. $\frac{C_1 \times C_2}{C_1 + C_2}$ b. $C_1 + C_2 + C_3 \cdots$ c. $\frac{C}{D}$

d. $\frac{1}{\frac{1}{C} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots}$

Name ______________________

Test B

Directions

Do the following problems.

1. In reference to a capacitive AC circuit complete the following statements by the word "increases" or "decreases".

   a. as frequency increases, Xc ______________________

   b. as frequency decreases, E_R ______________________

   c. as frequency decreases, Ec ______________________

   d. as frequency increases, I_{Line} ______________________

   e. as capacitance increases, Xc ______________________

   f. as capacitance decreases, I_{Line} ______________________

2. Write the formula for Xc in

   a. series

   b. parallel

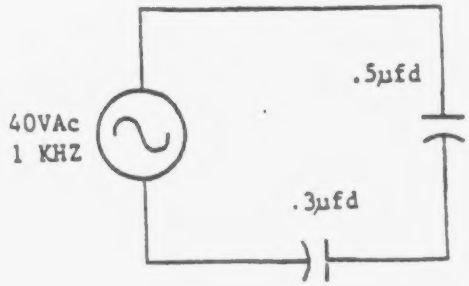
3. Find the capacitive reactance of a 250 PF capacitor at a frequency of 3.75 MHz.

   Xc______________________

4. Solve for Ic and Ec.

   Ic ______________________

   Xc_T ______________________

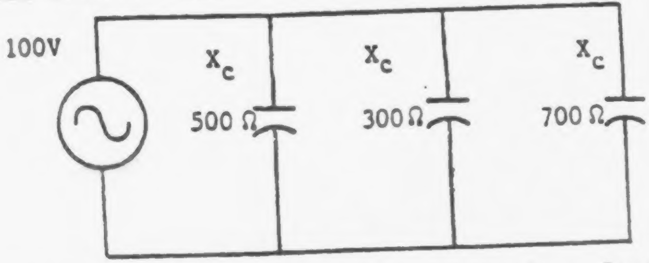


Test B, continued

5. At what frequency will a .033 μF capacitor have an Xc equal to 100 Ω ?

6. What capacitance is needed to have a 500 ΩXc at 5 MHz?

7. How much current will flow in the circuit below? Ic ______________



8. A capacitor in an AC circuit will cause the voltage to__________________ the current.

9. If you were going to lower the reactance of a capacitive circuit, which of the capacitors would you choose:

   a. .50 μfd

   b. 5000 PF

   c. .05 μf

   d. 5 μfd

10. Define capacitive reactance.

Yes No Did you consider this a useful package? (Circle your choice)

Capacitance

Capacitance : điện dung: đặc tính của một mạch điện có khuynh hướng gia tăng điện năng trong mạch để có một điện thế nhất định.

Plate : đĩa; miếng mỏng bằng kim loại và dài dùng trong tụ điện (capacitor)

store : chứa; trữ.

charge (n): điện tích

charge (vt): nạp điện; xạc điện.

puncture (n): lỗ thủng.

(vt) : đâm thủng; châm thủng.

dielectric = insulator : chất cách điện (không dẫn điện).

Occur : xảy đến; xảy ra.

Referred to as : được biết như là.

Leaky : rò; chảy.

Considered: coi như là

function (n) công việc

functionally (adv): về cơ năng.

destroyed : phá huỷ

breakdown : ngừng chạy

breakdown voltage: điện thế ngừng chạy; (mất điện thế).

cause = induce: gây ra.

ability : năng lực; khả năng

opposite a change in voltage: chống lại sự thay đổi của điện thế.

Farad : đơn vị căn bản của điện dung viết tắt là : F

Capacitive Reactance: dung kháng ký hiệu : X_C

1. C

Computer (n) : máy tính điện toán.

compute (vt) : tính toán

Compute by the formula : được tính bằng công thức.

$X_C = \frac{1}{2\pi \cdot f \cdot C}$, Công thức tính dung kháng.

X_C : Capacitive Reactance

C : Capacitance

π : 3,14

f : Frequency

mà X_C : tính bằng ohm

f : tính bằng Hertz

C : tính bằng Farad.

Capacitor : tụ điện

Consisting of : gồm có

Separate by : tách biệt; tách riêng

dielectric strength : cường độ, sức (cách điện)

withstand = opposite : kháng cự; chống lại.

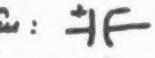
Specific thickness : độ dày đặc biệt.

discharge = release : phóng thích.

removing # neutralizing :
sự chuyển dời   làm trung hoà.

electrolytic capacitor : tụ điện điện giải

ký hiệu :



a thin oxide layer : một lớp ô-xít mỏng.

layer : lớp; màng.

surface : bề mặt

the advantage : sự tiện lợi; lợi ích.

design (n) : kiểu; mẫu

design (vt) : phác hoạ; vẽ kiểu.

designated : được chỉ định.

Relatively : quan hệ; liên hệ

small case size : cỡ chén nhỏ.

case : hộp; tổ (cỡ tụ điện được cấu tạo).

polarity : cực (⊕ hay ⊖).

polarized : phân cực.

nopolar : không cực.

nonpolarized : không phân cực

general (a) : toàn thể; tổng.

generally (adv) : thường

generate (vi) : sản xuất; sinh ra

2.C

presence (n) sự có mặt; lân cận.

remain : còn xót lại; giữ lại.

electrostatic field: tĩnh điện trường

field : điện trường

exist : tồn tại.

therefore : cho nên

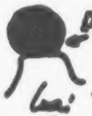
practical units : các đơn vị thực hành.

microfarad : viết tắt: µFD; MFD; MF.

picofarad : (pFD; pfd; pf.)

regardless : không quan tâm; không cần để ý.

Disc : đĩa (tròn) chỉ loại capacitor



paper capacitor : loại tụ điện giấy

mica capacitor : tụ điện mê-ca.

mylar capacitor: tụ điện mylar

category : loại, thứ.

accumulate = stored : chứa, trữ; tích lũy.

accumulator : bộ tích lũy; bình điện.

particular : riêng biệt.

RC time constant: hằng số thời gian RC.

Công thức: T = R×C

T: tính bằng giây.

R: tính bằng ohm.

C: tính bằng farad.

Reactance : điện kháng.

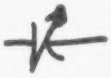
Temperature coefficient: hệ số nhiệt độ.

Temperature: nhiệt độ.

variation : sự đổi khác

degree celsius: độ C. °C (độ tính theo Cen ci-uýts)

variable capacitor: tụ điện biến đổi.

Ký hiệu:  working voltage: điện thế hoạt động. điện thế tối đa có thể áp đặt điện vào một tụ điện mà không gây ra nguy hiểm khi có (tia) hồ quang. working voltage được chỉ định như là WVDC, WV hay VDC.

$\underbrace{\text{WVAC} = .707 \times \text{WVDC}}$

Risking : rủi ro.

breakdown : ngưng chạy; chết máy; không còn hoạt động.

permanent damage: thiệt hại vĩnh viễn.

Foil : kim loại lá (được cán mỏng thành giấy kim

loại.)

metal plates = foil sheets: tấm kim loại (bản cực của tụ điện)

electrical charge: điện tích điện.

Hence : từ đây.

Condenser : bộ tụ lỏng; bộ tụ điện. Condenser là tên cũ của Capacitor.

encounter : gặp mặt; gặp…

filter : bộ lọc.

blocking : tụ điện cản.

coupling : liên kết; kết hợp từng cặp.

Combine : kết hợp.

Resonant : cộng hưởng.

Resonant circuit : mạch cộng hưởng

used for tuning : dùng để điều chỉnh.

available : có sẵn; hữu dụng

fixed : cố định

variable : biến đổi

RF : Radio Frequency (cao tần)

receiver : người nhận.
transmitter : người gởi.
Shape : hình, kiểu.
trimmer : núm đổi ánh sáng đèn.
padder : tụ điện liên ứng (tụ điện biến thiên nhỏ ghép nối tiếp với một tụ điện lớn).
Trimmer : còn gọi là tụ điện (thăng bằng): gồm tụ điện bán điều chỉnh nhỏ nối song song với tụ điện lớn để điều chỉnh ánh sáng đèn.
rotary capacitor : tụ điện quay (xoay tròn).
occasionally (adv): thỉnh thoảng.
As a general rule : như một qui tắc tổng quát.
critical : nguy cấp
viewpoint : quan điểm.

factor : yếu tố
premium : tiền tưởng lệ (tiền thưởng).
actual : hiện tại, có thực
vice - versa : lộn ngược, ngược lại; lộn lại.
approxiate : thích hợp.
subjecte (vt) việc(làm); làm việc.
Thus : thật vậy
substitute = Replace : thay thế
Replacement (n) : sự thay thế.
the same : giống nhau.
a percentage figure : một con số phần trăm.
nominal : có tên.
tolerance : độ sai biệt.
Leads : đầu (của tụ điện).
designation : (n) sự chỉ định tên; chỉ tên.
axial : thuộc về trục.
extend : kéo dài ra.
axle : cái trục.
retain : duy trì.

5-C.

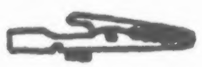
potentially : điện vị khác nhau.
dangerous : nguy hiểm nhất
exist : tồn tại
across : ngang qua
precaution : sự đề phòng.
observe : quan sát.
treat : đối xử
grab : vồ; tóm lấy.
Case (n): vỏ; hộp (chỉ cái vỏ của capacitor).
giant : khổng lồ; vĩ đại.
contain : chứa đựng.
immediately: ngay lập tức
briefly : ngắn, gọn.
Reduce : giảm
sparking : sáng , tia lửa loé sáng.
case : trường hợp.
picture tube : đèn hình.
spot = point : điểm.
tube : ống tròn.
prone : thiên về; ngả về; nằm sấp.
exploding : nổ tung.
explode (vt) nổ.
double , gấp đôi; 2 lần.
assembling : ráp
repairing : sửa chữa.
Compare : so sánh
margin : bờ, mép; rìa, lề.
least : ít nhất.
rating : số lượng.
capacitor testing : bộ phận dùng để khảo sát tụ điện.
condition test : dụng cụ khảo sát điều kiện (tốt xấu) như khảo sát tụ điện : chạm (mát); rò; hở mạch.
value test : dụng cụ khảo sát về trị số dung kháng của capacitor.
condition : điều kiện.
instrument : dụng cụ.
analyer , bộ phận phân tích.
perform (vt) làm; thi hành.

6-C.

outline : ngoại tuyến; phần ngoài.
outlined : phần chỉ dẫn.
Isolate : để riêng ra; để xa ra.
prevent : cản, ngăn.
shock : giật. (điện giật)
damage (n): sự thiệt hại; nguy hiểm.
extremely : cực độ.
nonelectrolytic : không điện giải.
exhibit : trình bày.
assigned : chỉ rõ.
measurable : có thể đo.
even if : mặc dù
excess : thái quá
similar manner : kiểu tương tự.
response : trả lời.
meshed : - bắt vào lưới (sa vào lưới: chỉ charge ở trong plate)
mesh (vt): - sa vào (charge ở trên plate),
unmesh : - charge lìa khỏi plate).
Simple technique : Kỹ thuật đơn giản.

mesh + unmesh : có nghĩa là điện tích ở trên plate của tụ điện rời từ từ lìa khỏi plate của tụ điện khi khảo sát tụ điện trong trường hợp phóng thích điện tích. Nghĩa đen của mesh: là bắt bằng lưới; sa vào lưới. unmesh : lìa khỏi lưới.

bending : uốn cong
away : lìa khỏi.
simplist : đơn giản nhất
suspect : nghi ngờ, ngờ vực.
substitution : sự thay thế.
characteristic : đặc sắc, đặc tính.
alligator clip leads : loại kẹp hàm răng cá sấu



Eleminate	:	loại trừ, loại ra.
original	:	nguồn gốc
Replace	:	Thay thế
Leakage (v)	:	rò, chảy
(n)	:	sự rò, sự chảy.
Reserve	:	dành riêng, dự trữ.
Exclusively	:	độc quyền, không cho xen vào.
Although	:	mặc dầu
Built	:	xây dựng, dựng nên.
If neither	:	nếu không; nếu cũng không
Possibility	:	có thể xảy ra
feasible	:	thực hiện được
substitute (V)	:	thay thế
substitution (n)		sự thay THẾ.
involve	:	gồm, bao gồm, kéo theo, ám chỉ
Revolve	:	làm bận trí, làm cho quay quanh.
Suspect	:	nghi ngờ; ngờ vực.
Determine	:	xác định.
Require	:	đòi hỏi.
tester	:	dụng cụ dùng để trắc định.
Discuss (V)	:	bàn bạc; thảo luận
Discussion	:	sự bàn bạc; thảo luận; bàn thảo.
Versatile	:	phổ biến
Idea	:	ý tưởng; ý nghĩ.
perform (vt)	:	thi hành; làm (việc)
function	:	chức năng; làm việc.
Ability	:	khả năng; năng lực
Release	:	phóng thích.
useful	:	hữu dụng; có ích lợi.
photostrobe	:	- tần kế - quang kế (loại đèn dùng ánh sáng để trắc định hay đo việc đánh lửa của động cơ còn gọi strobescope.)

8.C.

Eleminate : loại trừ, loại ra.
original : nguồn gốc
Replace : Thay thế
Leakage (v) : rò, chảy
(n) : sự rò, sự chảy.
Reserve : dành riêng, dự trữ.
Exclusively : độc quyền, không cho xen vào.
Although : mặc dầu
Built : xây dựng, dựng nên.
If neither : nếu không; nếu cũng không
Possibility : có thể xảy ra
feasible : thực hiện được
substitute (v) : thay thế
substitution (n) : sự thay thế.
involve : gồm, bao gồm, kéo theo, ám chỉ
Revolve : làm bận trí, làm cho quay quanh.

Suspect : nghi ngờ; ngờ vực.
Determine : xác định.
Require : đòi hỏi.
tester : dụng cụ dùng để trắc định.
Discuss (v) : bàn bạc; thảo luận
Discussion : sự bàn bạc; thảo luận; bàn thảo.
Versatile : phổ biến
Idea : ý tưởng; ý nghĩ.
perform (v) : thi hành; làm (việc)
function : chức năng; làm việc.
Ability : khả năng; năng lực
Release : phóng thích.
useful : hữu dụng; có ích lợi.
photostrobe : - tần kế
- quang kế
(loại đèn dùng ánh sáng để trắc định hay đo việc đánh lửa của động cơ còn gọi strobescope.)

8.C.

strobe light :	Đèn đo việc đánh lửa của động cơ còn gọi tắt là strobe.
weld :	hàn (như hàn gió đá)
welding :	việc hàn, sự hàn, các loại hàn.
ignition system:	Hệ thống đánh lửa (kích lửa)
ignition :	- thời chuẩn - đánh lửa
timing :	- thời chuẩn (của động cơ)
Applicable for:	có thể ứng dụng cho.
Precise :	đúng chính xác.
Oscillator :	đèn tách sóng biến đổi từ năng lực điện một chiều (DC) thành năng lực xoay chiều (AC).

Couple (v) :	nối, buộc thành đôi.
(n) :	từng đôi; từng cặp.
coupling (n):	từng cặp, từng đôi.
stage :	tầng; chặng nghỉ.
multistage :	bội tầng
distortion :	sự biến dạng.
occur :	xảy đến
block (n):	- dãy; hàng, khu nhà, ô.
(vt):	- cản trở.
filter (n)	lọc, bộ lọc.
filtering (a)	- lọc
element :	phần tử, yếu tố, nguyên tố.
filtering elements :	các bộ phận lọc.
smooth (vt):	làm phẳng; làm dịu (ở đây chỉ output, công suất phát và tín hiệu sau khi qua tụ điện thì cường độ và điện thế sẽ được nắn theo đường thẳng.

9-C.

Smooth out :	tín hiệu phát ra sau khi qua tụ điện bị nắn lại thành đường thẳng. nếu AC: tín hiệu như : (AC) → nhưng DC tín hiệu qua tụ điện trở thành smooth out có sóng thẳng (DC) → ————.
flat :	bẹt ra; kéo dãn ra. chỉ ———— thay vì .
selective (a)	chọn lựa.
accept :	chấp nhận
Reject :	từ chối
certain :	chắc chắn
tune :	sự hòa hợp âm điệu
tuned circuit:	mạch hòa hợp. (mạch có điện dung, cảm điện, điện trở nối tiếp hoặc song song khi được kích thích bởi tần số cộng hưởng sẽ có sự biến đổi năng lượng giữa cuộn dây và tụ điện)

tuning circuit:	mạch bảo hòa (mạch điện chỉnh đúng chuẩn)
tuning (a) :	chỉnh ; hòa hợp.
silver mica capacitor :	tụ điện mi ca.
precision (n):	sự chính xác.
stability. (n)	sự kiên cố, chắc chắn.
dependability:	đáng tin cậy, chắc chắn.
suit (vt),	làm vừa lòng, làm thích hợp.
miniature :	thu nhỏ.
Exhibiting :	sự trình bày.
moisture ,	sự ẩm ướt, không khí ẩm.
property :	bản chất, vật sở hữu.

10-c.

Relax (vi):	duỗi, lỏng (ra)
Relaxation (n):	sự duỗi ra.
network :	Hệ thống.
dependent upon:	tùy theo, dựa trên.
Time constant:	Hằng số thời gian (có 5 hằng số).
1T:	một hằng số thời gian = 63.2%
2T:	hằng số thứ 2 bằng 86.4%
	(3T, 4T, 5T) có trị số phần trăm 94.9%, 98.1% và 100%.
Permit (vt):	cho phép
block (vt):	cản trở (không cho phép)
unique :	độc nhất, duy nhất.
figure :	con số, hình ảnh.
fraction :	phân số.
Compensate :	đền bù, bồi thường
decimal point :	chấm thập phân

phase Relationship :	sự quan hệ góc.
deal with :	đối phó với; đối với.
in phase :	cùng góc
lead :	dẫn, dẫn đầu
appendix :	phần phụ lục, phụ lục.
describe :	mô tả
Signifigant :	chứng tỏ, làm rõ nghĩa.
classification:	sự phân hạng, loại.
energize :	kích thích
arrow :	mũi tên
row :	dãy, hàng
specification :	sự minh thị (nói rõ)
standard :	tiêu chuẩn.
coefficient :	hệ số
specify :	ghi rõ.
texts :	đầu đề
Temperature:	nhiệt độ.
memorize :	nhớ; ghi nhớ.
Shift :	dịch chỗ; thay đổi chỗ.
align :	xếp thành hàng; xếp theo dãy.

11. C.

电容 (CAPACITANCE)

技術語彙

breakdown voltage：擊穿电压，破坏电压，潰決电压.

applied：应用於，使用於，提供.

plates of a capacitor：电容器板

puncture：擊穿，刺破

dielectric：绝缘体

referred：被認為，歸咎於，参照.

leaky = 漏，漏电.

functionally：操作上地，運用上地

destroyed：被破坏，被損坏

capacitance：电容，(传導体的)容量.

store = 蓄存.

charge = 电荷，电量.

oppose：使相对，对立.

farads：法拉(人名)(电容單位).

capacitive reactance：容抗(X_c)

capacitor = 电容器.

metal plates：金属板

separated by…：被…分隔.

provides = 供应

strength：強度

withstand：抵抗，经得起

without：而不会--

discharge = 放电，放电的.

removing：移去，除去.

neutralizing = 使不带电，使中性.

electrolytic capacitor = 电解电容器.

LIII-UII-10,-11,-12,-2

electrostatic field：静电场.

practical＝实際上的 事实上

nonpolarized＝非極性的, 无極性的.

disc capaciter．盤形电容器

paper capaciter＝紙質电容器

mica capaciter＝雲母电容器

mylar capaciter：麦拉电器容.
(一种化學品)

category：种類，類目.

accumulate：儲集；蓄集

polarized：極化．使帶極性

particular＝特别的.

RC time constant＝RC時间常數.
RC = resistance－capacitance

reactance＝电抗 (X)

temperature coefficient＝
温度係數

degree celsius＝攝氏温度數
celsius = centigrate

variable capaciter＝可变电容器

mechanical means：机械方法.

working voltage：工作电压，運
行电压

risking＝冒…險

permanent damage：永遠損坏

definitions：定義.

general category＝此類目的概
括性的…

appropriate time＝適当地時

steadily＝穩定地.

ceramic＝陶瓷.

foil sheets＝薄膜片(層).

blocking：闭塞．中断．间歇.

signal coupling：信號联结

resonant：共振的，共鳴的，諧振

trimmer：微調电容器(整修

padder：微調电容器(活負式

LIII-U11-23,-24.

fixed : 固定的

critical : 鑑定的. 臨界的

viewpoint = 觀点.

premium : 額外的價格. 优質. 质量改進的.

one-millionth : 百萬分之一

vice-versa = 反轉过来.

be subjected = 被接受.

direct replacement = 直接替代

tolerance = 誤差

percentage = 百分比

variation : 变化, 改变

specified = 被(特定)指示出的

nominal = 名義上的, 表面上的, 票面上的, 標示出的.

actual = 事实的, 实際的.

leads = 引线

axial = 軸

extend : 延長, 跨过

parallel : 並排, 並联.

capacity safety = 电容器安全性

filter = 过濾器

retain : 保留.

exits = 超过

potentially dangerous = 潛在地危險的

precaution = 预先注意

observed = 遵守. 進行

grab = 抓握.

briefly = 短暫地

prone = 易患的 ---

exploding : 爆炸.

double check = 重複檢查

LZZZ-UII-25

safety margin = 安全界限

condition test = 條件測驗、狀況測查.

value test : 數值測查(檢查)

physical condition = 實物狀況

determine = 確認,確定.

instrument = 儀器,儀錶

perform : 完成,履行

tester : 檢查器

analyzer = 分析器(儀)

continuity = 連續性,連通性

isolate = 隔绝,孤立

prevent = 防止

possible damage = 可能損壞

shock : 电擊.

response : 回答,反应

rotary = 旋轉的

fully meshed : 完全嚙合.

unmesh = 不嚙合,不相配对合.

shorted = 短路的.

corrected = 改正,修改.

accurately = 精確地

suspected = 懷疑的

substitution : 替換,代用

characteristics : 特性、本性

technique = 技術

alligator clip : 鱷魚形夾子

eliminates : 消除,排除.

reserved : 被预定,被保留

exclusively = 獨一的,唯一的

like value = 相同值

requires = 需要.

find out = 去知道

extremely：非常地、激度地.

versatile：多功能的，多用途的.

photostrobe：光电頻闪視測器

welding units：焊接器

ignition：點火，引燃，发火

capacitive discharge：电容放电

oscillaters：振盪器，断續器

strobe lights＝闪光燈

block：闭塞.

multistage amplifier＝多级放大器，联级放大器

coupling capacitor：耦合电容器

distortion：畸变，失真

filtering elements 濾波零件

smooth：平滑，穩定

flatten：平整

tuned circuit：調諧电路

transceiver：无线电收发两用机，步談机.

tantalum capaciter：鉭元素电容器

precision：精確

close tolerance：小誤差

stability：安穩性.

dependability＝可靠性

transister circuit：晶体管电路

miniature assemblies：微型組

timing circuit：定時电路，計時电路

by-pass 旁路，分路，分流.

exhibiting：顯出，現出.

moisture＝潮濕

resistant：＝防阻(性)的.

series string：串联行列

equal：相等

unequal：不相等.

LIII-U11-27,-28,-29,-30, EL-.

similarity =相似性.相類似地.

network =網路

relaxation oscillator 張弛振盪器

recall = 选出, 二次呼叫.喚起

unique = 唯一的.

phase relation :相位関係.

comparison : 比較

resistive circuit: 电阻的电路

capacitive circuit: 电容的电路

stacked sheets =叠(集)層片.

rolled foil = 捲筒型膜.

tubular 管形

six-dot system = 六圓点系统

row = 排, 橫排.

standard : 標準

significant figures: 有效數字

EIA class =

temperature coefficient =温度係數.

Appendix = 附錄.

thickness =厚度.

thicker =較厚的

obsolete =廢棄的,陳舊与用的

major : 主要的.

disassemble =拆散, 分解.

encapsulated =装入膠囊, 压縮

multiple section = 多段.

spark : 火花.

snapping : 急速的啪一声.

instant: 瞬间

instataneous charging : 瞬時充电

surge = 冲擊波, 电湧, 浪湧.

jolt = 震动.震擊.搖动.

EL-8C-21, -25-29

charging current：充电电流

verify：証実，証明

disprove：舉反証，証明……的錯誤，駁斥.

defective：有缺陷的，有故障的.

arced across：电弧跨越，

needle deflection：指針偏移.

EMF = electromotive force 电动势

counter EMF：反电动势.

inductive circuit：有感电路，电
感电路.

negligible：很小的，可以忽略不計的

audio generator：音频发生器.

ext synch = external synchronizer 外部同步器

shift：移位，移动

deficiency：虧數，虧格，不足，

ELECTRO CURRICULUM

VOCATIONAL TRAININ SSON PLAN / X

R, C, L Circuits

Teaching Materials Source ____________________

Chapter ____________, pages ____________

Lab Manual pages ____________

Additional Instructor Materials ____________________

Main concepts student will learn:

1. to define the term impedance, indicate its letter symbol, and state the basic unit of measurement.
2. calculate the total impedance of series and/or parallel resistor, capacitor, and inductor circuits utilizing the proper formulas and solving for the unknown.
3. explain electrical resonance and list the essential characteristics of series and parallel resonant circuits.
4. identify several practical applications of tuned circuits, and draw the schematic diagram of at least forur basic types of filters.
5. state the formula for the resonant frequency of any RCL circuit.
6. select either a series or parallel resonant circuit form a group of circuit diagrams as specifically requested.

Technical Vocabulary

see Glossary

Related General Vocabulary

see Glossary

Teaching Activity

1. Be sure when reviewing to stress that in a RCL circuit the various reactances and resistance values cannot be just added in order to determine total circuit impedance.
2. Some instructors either omit or gloss over a very effective teaching technique called vector analysis. This system can minimize the need for cumbersome mathematical computations and is a natural for classroom use.
3. In addition to formal lecture topics, spend a moment describing the concept of stray capacitance and inductance. Although stray quantities are usually low in value, they can cause faulty operation of some circuits. Describe some basic wiring techniques to help reduce this problem, and remember this kind of instruction can promote better craftmanship during laboratory experiments or project construction.
4. Do not forget to summarize ohm's Law for alternating current in respect to capacitive reactance, inductive reactance, and impedance. Review, discussion, and possible evaluation of this suggestion idea during instruction can avoid technical disorientation.

Materials and Notes

Length of Lesson

2 weeks

Evaluation

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral or written testing procedures.

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 13"

1. Identify the conditions that occur in a series RCL circuit at resonance. (Place a check mark in the answer box corresponding to all correct answers).

   A. $X_L = X_C$ 1A. ☐

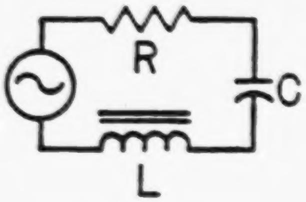
   B. $Z = R$ 1B. ☐

   C. Current is maximum 1C. ☐

   D. Impedance is maximum 1D. ☐

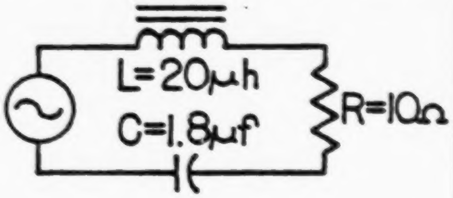
   E. Current is minimum 1E. ☐

   F. Impedance is minimum 1F. ☐



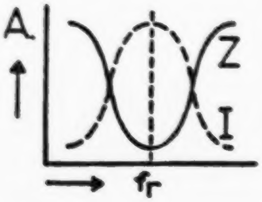
2. State the formulas for finding the resonant frequency of any RCL circuit. 2. ☐

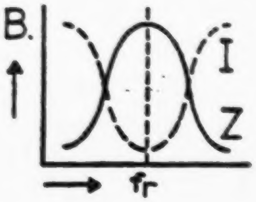
3. Solve for the "f_r" of the circuit below. 3. ☐



Show work

4. Identify the figure representing the response curve of a series RCL circuit. 4. ☐





5. Using the terms; resistive, capacitive and inductive, explain how a series RCL circuit appears:

   A. When the applied frequency is below the resonant frequency. 5A. ☐

   B. When the applied frequency equals the resonant frequency. 5B. ☐

Name: ____________

Date: ____________

Period: ____________

RCL CIRCUITS
TECHNICAL GLOSSARY

ACCEPTOR CIRCUIT:	A series, capacitor-inductor circuit which offers minimum impedance (total AC resistance) at resonance. Thus, accepts or passes signals at resonant frequency.
ATTENUATION:	The process of decreasing the amplitude of a signal, usually to minimum or zero value.
BAND PASS FILTER:	A filter circuit designed to pass signals within a predetermined continuous band of frequencies, and attenuate frequencies above and below that band.
FILTER:	An electrical circuit utilizing an inductor, capacitor and/or resistor to eliminate or attenuate specific frequencies or bands of frequencies.
IMPEDANCE:	The total resistance to AC current flow offered by a circuit containing resistance, capacitance, and inductance. Letter symbol: Z
LC CIRCUIT:	A circuit containing both inductance and capacitance.
PARALLEL RESONANCE:	A parallel LC circuit which offers maximum resistance to current flow at resonance, that is, when the capacitive reactance and inductive reactance are equal.
RC CIRCUIT:	A circuit containing both resistance and capacitance.
RCL CIRCUIT:	A circuit containing resistance, capacitance, and inductance.
REJECT CIRCUIT:	A parallel LC circuit which offers maximum resistance (impedance) to current flow at resonance. The circuit will reject or block signals at the resonant frequency.
RESONANCE:	The single frequency in an LC or RCL circuit at which $X_L = X_C$.
RL CIRCUIT:	A circuit containing resistance and inductance.
SERIES RESONANCE:	A series RCL circuit which offers minimum opposition to AC current flow at its resonant frequency, (when $X_L = X_C$).
TANK CIRCUIT:	A parallel resonant circuit commonly used in radio and TV circuits to align the I.F. circuitry.
TUNED CIRCUIT:	A circuit containing capacitance, inductance and resistance in series or parallel, set to its resonant frequency, and utilized as a filter.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - MULTIPLE CHOICE

Select the term that best fits the given definition, and fill in the adjacent answer box.

1. A circuit containing both an inductor and a capacitor connected either in series or parallel.

   ○ IC circuit
   ⬡ RC circuit
   □ LC circuit
   △ RL circuit

2. The process of decreasing the amplitude of a signal to minimum or zero.

   ○ Resistance
   ⬡ Filter
   □ Resonate
   △ Attenuate

3. The opposition to AC current flow offered by an inductor.

   ○ Reactance
   ⬡ Impedance
   □ Resonance
   △ Resistance

4. A filter circuit designed to attenuate a single band of frequencies.

   ○ Band pass filter
   ⬡ Band reject filter
   □ Acceptor circuit
   △ Reject circuit

5. The total AC resistance offered by an RCL circuit.

   ○ Reactance
   ⬡ Impedance
   □ Resonance
   △ Resistance

6. The specific frequency in an LC circuit where $X_L = X_C$.

   ○ Reactance
   ⬡ Impedance
   □ Resonance
   △ Resistance

Name: ____________

Date: ____________

Period: ____________

7. An RCL circuit which offers maximum opposition to AC current flow at resonance.

   ○ Tuned circuit
   ⬡ Series resonance circuit
   ☐ Parallel resonance circuit
   △ Attenuation

8. An RCL circuit which offers minimum opposition to AC current flow at resonance.

   ○ Tank circuit
   ⬡ Series resonant circuit
   ☐ Parallel resonant circuit
   △ Attenuation

9. The opposition to AC current flow offered by a capacitor.

   ○ Reactance
   ⬡ Impedance
   ☐ Resonance
   △ Resistance

10. A filter circuit designed to pass a single frequency.

   ○ Band pass filter
   ⬡ Band reject filter
   ☐ Acceptor circuit
   △ Tuned circuit

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

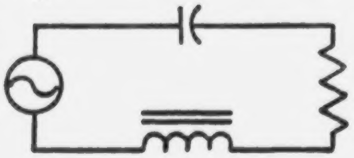
IMPEDANCE

MATCHING:

1. Impedance
2. RC circuit
3. RL circuit
4. RCL circuit
5. Reactance
6. Letter symbol for reactance.
7. Letter symbol for impedance.

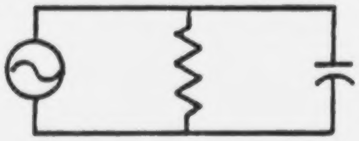
A. X

B.



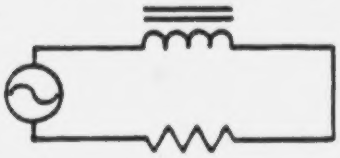
C. The AC resistance offered by a capacitor or inductor.

D.



E. The total opposition to AC current flow of a circuit containing resistance and inductance.

F.



G. Z

1. ☐
2. ☐
3. ☐
4. ☐
5. ☐
6. ☐
7. ☐

8. List the formulas for finding impedance in a series; (A) RC circuit, (B) RL circuit, (C) RCL circuit.

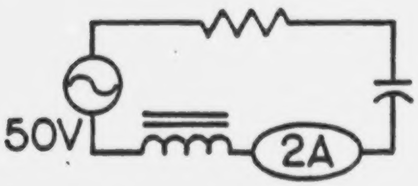
8A. ☐

8B. ☐

8C. ☐

9. Find the impedance in the following problem:

9. ☐



Show work

Name: ______________

Date: ______________

Period: ______________

10. Solve for the "Z" of a series RC circuit which has a resistance of 4 ohms, and a capacitive reactance of 3 ohms.

10.

Show work

11. Find the "Z" of a series RL circuit which has a resistance of 5 ohms, and an inductive reactance of 8 ohms.

11.

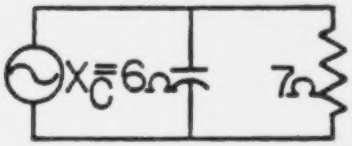
Show work

12. Utilizing the following formula for calculating impedance in a parallel RC circuit

$$Z = \frac{RX_C}{\sqrt{R^2+X_C^2}}$$

solve for "Z" in the following circuit.

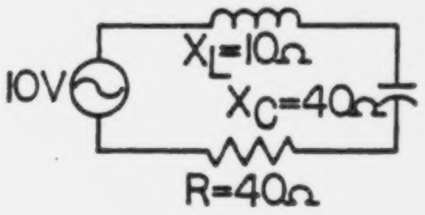
12.



Show work

13. Solve for impedance in the following RCL circuit:

13.



Show work

SCORE:

GRADE:

Name: ____________

Date: ____________

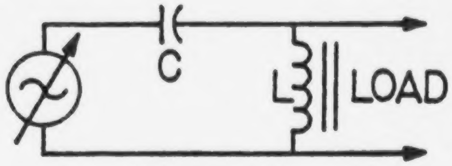
Period: ____________

WORKSHEET

RESONANCE AND FILTER CIRCUITS

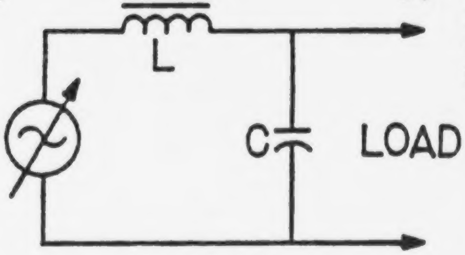
Identify the following filter circuits by matching the circuit drawing with its functional description. (Hint: unscramble the letters beneath each circuit for a clue).

1.



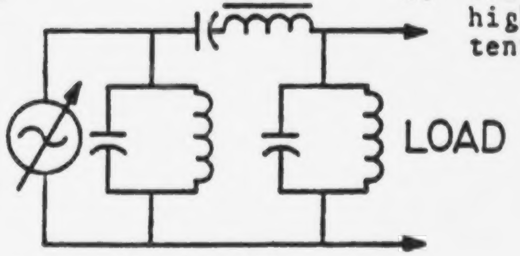
(SSHPGIHA)

2.



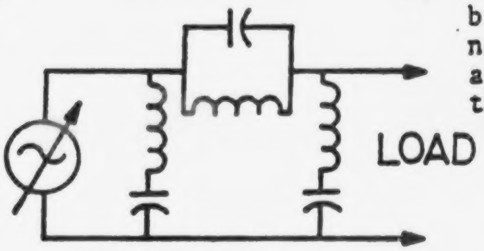
(WPOSSLA)

3.



(BASSDAPN)

4.



(RENTDAJBEC)

A. This circuit will pass only a desired band of frequencies, on or near resonance, and block all other frequencies from reaching the load.

B. A filter designed to pass only frequencies below a desired value, and attenuate high frequencies.

C. This circuit will pass high frequencies and attenuate low frequencies.

D. A filter designed to block frequencies on or near resonance, and pass all other frequencies to the load.

1. ☐

2. ☐

3. ☐

4. ☐

5. The resonant frequency of a circuit is that frequency which causes X_L to equal ________.

5. ☐

Name: ______________

Date: ______________

Period: ______________

6. List the formula for finding resonant frequency (f_r). __________ 6.

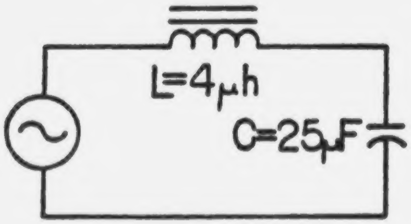
7. The unit of measurement for f_r is the __________. 7.

8. A circuit can have more than one resonant frequency. (T-F). 8.

9. If a series RCL circuit is operating at resonance, current flow will be __________. (Minimum or maximum) 9.

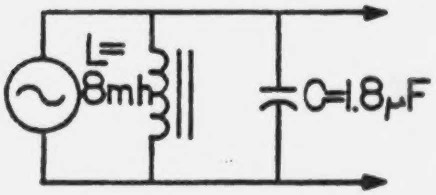
10. When a parallel LC circuit is functioning at resonance, the circuit current will be __________. (Minimum or maximum) 10.

11. Solve for the resonant frequency of the series LC circuit below. 11.



Show work

12. Calculate "f_r" for the parallel LC circuit below. 12.



Show work

Name: ______________

Date: ______________

Period: ______________

C. When the applied frequency is above the resonant frequency. 5C. ☐

6. Identify the conditions that occur in a parallel LC circuit at resonance (check the appropriate box).

A. $X_L = X_C$ 6A. ☐

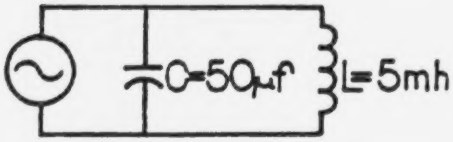
B. Current is maximum 6B. ☐

C. Impedance is maximum 6C. ☐

D. Current is minimum 6D. ☐

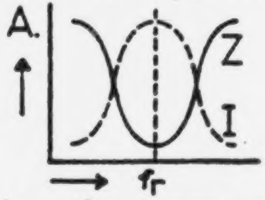
E. Impedance is minimum 6E. ☐

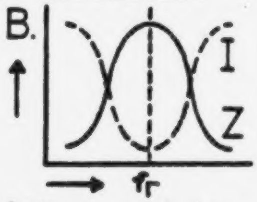
7. Solve for "f_r" in the problem below. 7. ☐



Show work

8. Select the response curve which represents the action of a parallel LC circuit at resonance. 8.





9. Using the terms; resistive, capacitive, and inductive, explain how a parallel LC circuit appears:

A. Below resonance 9A.

B. At resonance 9B.

C. Above resonance 9C.

10. Filter circuits utilize the frequency sensitivity or reactance of (A)__________ and (B)__________ (components) to form frequency selective circuits. 10A. 10B.

Name: ____________

Date: ____________

Period: ____________

11. An inductor tends to pass (A)__________ (high or low) frequencies, while a capacitor tends to pass (B)__________ (high or low) frequency signals.

11A. ☐

11B. ☐

12. Draw a schematic diagram for a low-pass filter.

13. Draw the schematic diagram for a high-pass filter.

14. Draw a schematic for a band-pass filter.

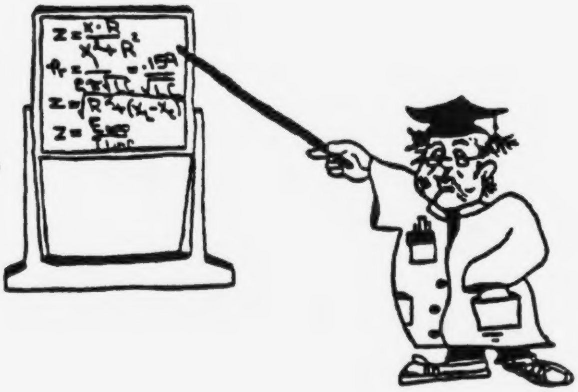
Name: ____________________

Date: ____________________

Period: ____________________

INFORMATIONAL HANDOUT

IMPEDANCE, RESONANCE, AND FILTER CIRCUITS


$Z = \frac{X \cdot R}{X^2 + R^2}$
$Z = \sqrt{R^2 + (X_L - X_C)^2}$

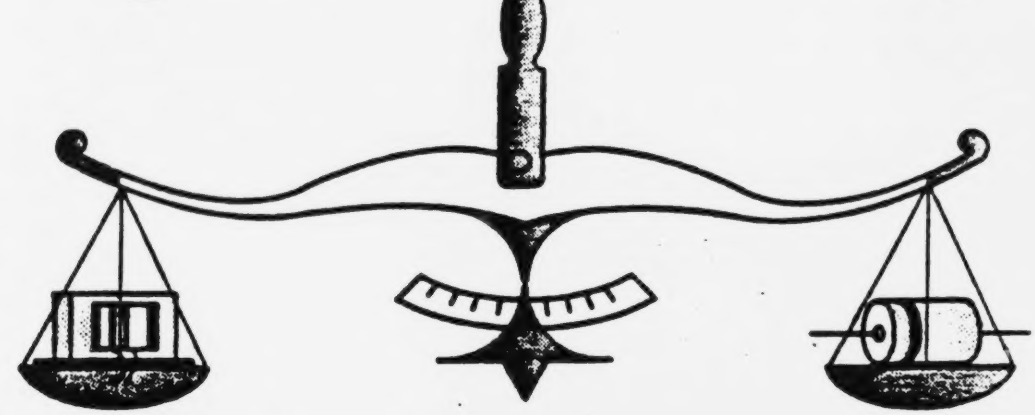
IMPEDANCE

The impedance of a circuit represents the total "AC resistance" of a circuit containing resistance and reactance; that is, resistance, X_L and/or X_C. The letter symbol for impedance is Z, and impedance can be solved for by using one of the following formulas.

$Z = \frac{E_{app}}{I_{line}}$	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$Z = \frac{X \cdot R}{X^2 + R^2}$ WHERE $X = \frac{X_L \cdot X_C}{X_L + X_C}$
General Formula	Series Impedance	Parallel Impedance

RESONANCE

$$X_L = X_C$$



Name: ____________________

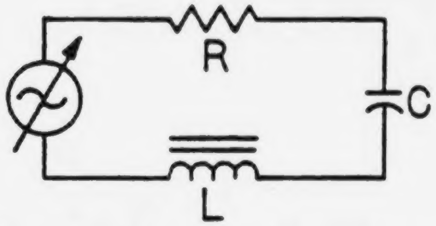
Date: ____________________

Period: ____________________

A resonant condition occurs in an RCL circuit when $X_L = X_C$. As you know, capacitive reactance and inductive reactance vary with frequency (as frequency increases X_L increases, but X_C decreases). Thus, X_L and X_C have opposite response to frequency and the single frequency where $X_C = X_L$ is called the resonant frequency (f_r) of the circuit. The "f_r" of a circuit can be found using the following formulas:

$$f_r = \frac{1}{2\pi\sqrt{LC}} \text{ or } f_r = \frac{.159}{\sqrt{LC}}$$

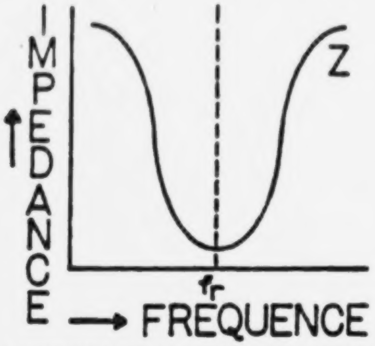
CHARACTERISTICS OF A SERIES RESONANT CIRCUIT



Basic series RCL circuit.

A series RCL circuit at resonance offers minimum impedance (Z) to current flow. When the applied frequency is varied, however, the value of impedance increases. The impedance of a series RCL circuit can be plotted on a graph to show the effects of a varying frequency.

The figure below is an impedance response curve for any series RCL circuit. The graph shows the effects of varying the applied frequency above and below the resonant frequency (f_r), and the summary, to the right, explains the operational characteristics.

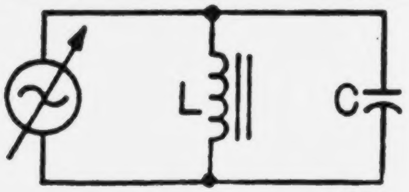


At resonance; the series RCL circuit offers minimum impedance, thus allows maximum current flow at resonance. The circuit appears resistive.

Below resonance; circuit appears capacitive, that is X_C is greater than X_L.

Above resonance; circuit appears inductive, that is X_L is greater than X_C.

CHARACTERISTICS OF A PARALLEL RESONANT CIRCUIT



Basic parallel LC circuit

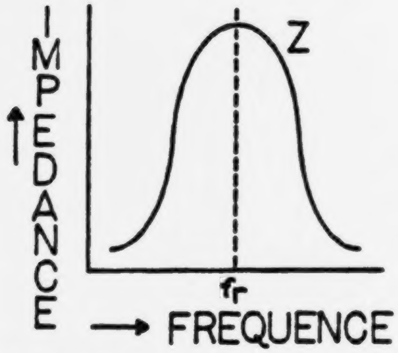
Name: ______________

Date: ______________

Period: ______________

A parallel LC circuit has a high impedance at its resonant point. When the applied frequency is varied above or below resonance, the impedance decreases or drops off.

The figure below shows the impedance response curve for a typical parallel LC circuit as the frequency is varied above and below the resonant frequency. The summary explains the circuits operational characteristics.



At resonance; the parallel LC circuit offers maximum impedance, and thus minimum current flow. The circuit appears resistive.

Below resonance; the circuit appears inductive. X_L is less than X_C, allowing more current flow in the inductor branch.

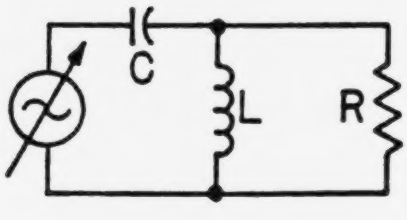
Above resonance; the circuit appears capacitive. X_C is less than X_L, allowing more current flow in the capacitor branch.

FILTER CIRCUITS

Filters are frequency selective circuits which utilize the operating characteristics of capacitors, inductors, and/or resistors to attenuate selected frequencies. Filter circuits can be divided into broad catagories; "frequency selective", or "power supply" filters. We will now discuss four basic frequency selective filters.

HIGH-PASS FILTER

A high-pass filter takes advantage of the characteristics of a capacitor and inductor to provide a circuit which will pass only frequencies that occur higher than a desired value and attenuate lower frequencies. The frequency value is determined by the selection of C and L.



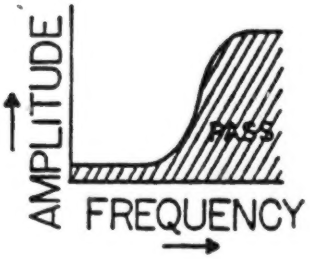
CIRCUIT CHARACTERISTICS:

1. The majority of the "low frequency signals applied to the filter will be blocked by the capacitor due to a high X_C.
2. "Low frequency" signals that move through the capacitor will be shunted past the load, through the inductor, due to a low X_L.

Name: ____________________

Date: ____________________

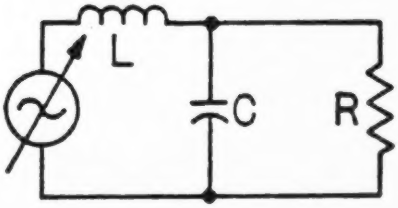
Period: ____________________

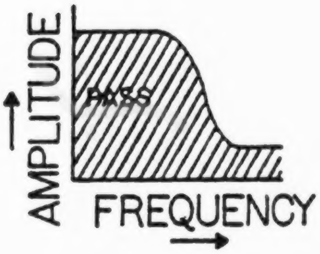


3. High frequency signals will be passed by the capacitor, due to low X_C, and blocked from flowin through the inductor, by a high X_L, thus only high frequency signals will be forced to move throug the load.

LOW-PASS FILTER

A low-pass filter again utilizes an inductor-capacitor network to develop a circuit which will pass only frequencies occuring lower than a desired value and attenuate higher frequencies. Again, the frequency value is determined by the value selected for L and C.



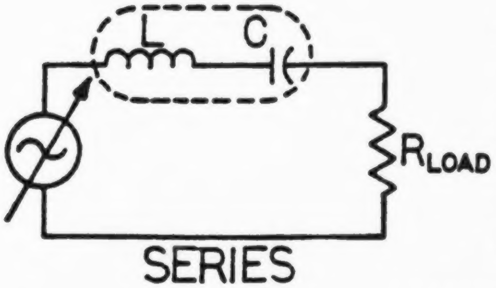


CIRCUIT CHARACTERISTICS:

1. The majority of the "high frequenc signals applied to the filter are blocked by the inductor due to a high X_L.
2. "High frequency" signals which m through the inductor will be shunted past the load by the capacitor, which offers low reactance to high frequency signals.
3. Low frequency signals will be passed by the inductor, due to low X_L, and blocked by the capacitor, which will exhibit a high X_C, thus only the low frequency signals wil be felt at the load.

BAND-PASS FILTER

Band-pass filters are designed to pass a narrow band of frequencies and block or attenuate all other frequencies. These characteristics can be obtained by utilizing either a series resonant or parallel resonant circuit.



CIRCUIT CHARACTERISTICS:

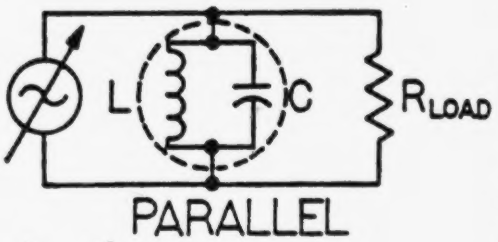
Series resonant circuit:

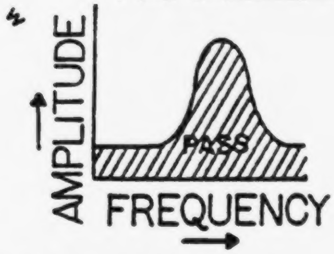
At frequencies near resonance, the impedance of the LC circuit is low, thus allowing current flow through th load. At frequencies above or below resonance the "Z" of the circuit increases, and blocks current flow.

Name: ____________________

Date: ____________________

Period: ____________________



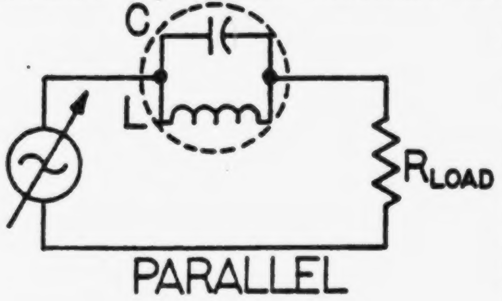


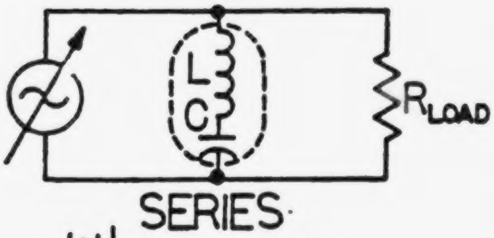
Parallel resonant circuit:

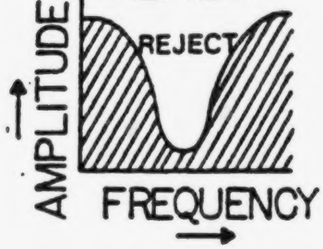
When frequencies near resonance are applied to the filter the parallel LC circuit offers high impedance to current flow, thus forcing the input signal through the load. As the applied frequency moves above or below resonance, the LC circuit offers a lower "Z" which allows the signal to be shunted through the parallel LC circuit and hence by pass the load.

BAND-REJECT FILTER

The function of a band-reject filter is to reject or attenuate a small band of frequencies on or near the circuits resonant frequency, and to pass all other frequencies. A band-reject filter can be designed utilizing either a parallel resonant circuit, or a series resonant circuit.







CIRCUIT CHARACTERISTICS:

Parallel resonant circuit:

On or near resonance, the parallel LC circuit offers high impedance, and blocks circuit current flow. As frequencies move above or below resonanc the "Z" decreases, and the signal will be present at the load.

Series resonant circuit:

At or near resonance, the series LC circuit offers low "Z", thus current will flow through the resonant circuit, while being shunted away from the load. As the input frequency move above or below resonance "Z" increases and the signal will then flow through the load.

INFORMATION SUMMARY

Resonance is the condition when the inductive and capacitive reactance in a circuit are equal and opposite, which cancel out the reactance, leaving only resistance in the circuit. Mathematically this is:

$$X_L = X_C$$

$$2\pi fL = \frac{1}{2\pi fC}$$

Resonant frequency (fr) is the frequency at which $X_L = X_C$ for a particular capacitor inductor combination. There can be only one resonant frequency for each LC combination since X_L increases with frequency and X_C is decreasing. The resonant frequency may be determined for a particular capacitor-inductor combination by using the following formula:

$$fr = \frac{0.159}{\sqrt{LC}} \text{ Hz}$$

The resonant frequency is inversely proportional to the square root of L or C. Any number of LC combinations will have the same resonant frequency if their LC product is the same. For a given LC product, the resonant frequency will remain the same. That is, if either L or C is increased by a factor of say, 10 or 20 and the other is decreased by the same factor, keeping the LC product constant, then the frequency will not change.

The L and C required to produce resonance at a certain frequency may be calculated with the following formulas:

$$C = \frac{0.0254}{fr^2L} \qquad L = \frac{0.0254}{fr^2C}$$

Where fr = resonant frequency in Hertz
C = capacitance in Farads
L = inductance in Henrys

Tuning means obtaining resonance at different frequencies by changing either the inductance or capacitance in a circuit.

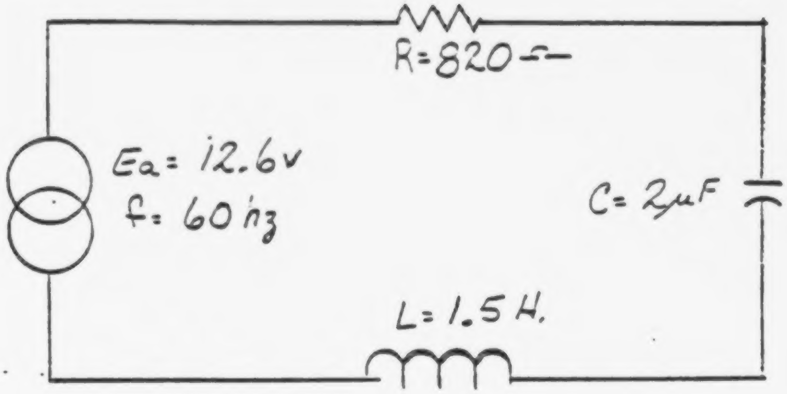
ELECTRONICS DEPARTMENT

Electronics 30

Read the text -- Grob 5th Edition -- Chapter 24, pages 468-481. Do PROBLEMS 1,2,3,4,5,6,7, & 8 pages 482 and 483.
or
Read the text -- Grob 4th Edition -- Chapter 25, page 498-515. Do PROBLEMS 1,2,3,4,5,6,7, & 8 pages 516 & 517.

Solve the following series RLC circuits. For your benefit, write the formula beside the answer.

1. X_L ____________
2. X_C ____________
3. X_T ____________
4. Z ____________
5. I ____________
6. E_R ____________
7. E_C ____________
8. E_X ____________

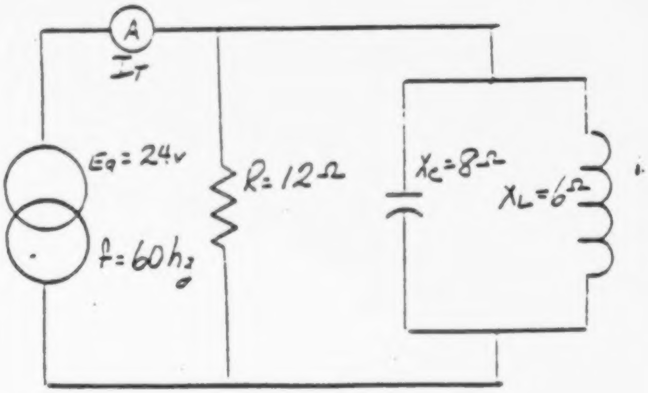


9. If the frequency of the AC source would double, what would be the effect on the following items? Answer with INCREASE, DECREASE, or REMAIN SAME.

X_L ____________ X_C ____________ Z ____________ I ____________

Solve the following parallel RLC circuits. For your benefit, write the formula beside the answer.

1. L ____________
2. C ____________
3. I_R ____________
4. I_L ____________
5. I_C ____________
6. I_X ____________
7. I_T ____________
8. Z ____________

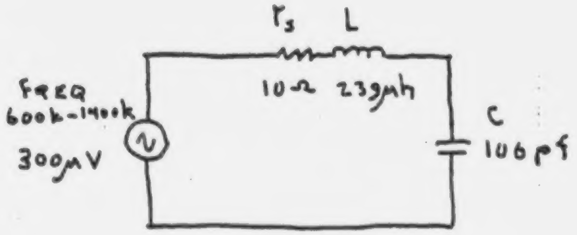


9. If the frequency of the AC source would double, what would be the effect on the following items? Answer with INCREASE, DECREASE, or REMAIN SAME.

PROB SHEET ______ NAME ______

TEXT: Grob Ch.27

Problem # 1


r_s
L
10Ω
239μh
FREQ 600k-1400k
300μV
C
106pf

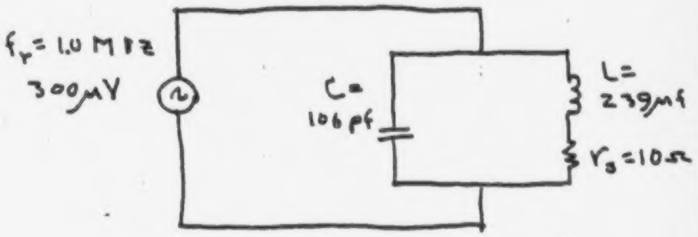
VECTOR DIAGRAM

CIRCUIT

	FREQUENCY	$X_L = 2\pi fL$	$-X_C = 1/2\pi fC$	NET. REACTANCE $X_C - X_L$	 $X_L - X_C$	Z_t	$I = V_t/Z_t$	$V_L = I X_L$	$V_C = I X_C$
	600 k								
	700 k								
	800 k								
	900 k								
f_r →	1 M								
	1.1 M								
	1.2 M								
	1.3 M								
	1.4 M								

PARALLEL RESONANCE

PROBLEM # 2


f_r = 1.0 MHz
300μV
C = 106pf
L = 239μf
r_s = 10Ω

VECTOR DIAGRAM

	FREQUENCY	$X_C = 1/2\pi fC$	$X_L = 2\pi fL$	$I_C = V/X_C$	$I_L = V/X_L$	NET LINE CURRENT $I_L - I_C$	 $I_C - I_L$	I_t	Z_t V_A/I
	600 kHz								
	700 kHz								
	800 kHz								
	900 kHz								
f_r →	1 MHz								
	1.1 MHz								
	1.2 MHz								
	1.3 MHz								
	1.4 MHz								

Exercise #1

CALCULATING THE RESONANT FREQUENCY (fr)

DIRECTIONS: Use the following resonant frequency formula:

$$f_r = \frac{0.159}{\sqrt{LC}}$$

to determine the resonant frequency of the following LC products or LC combinations.

1. $LC = 2500 \times 10^{-10}$

2. $LC = 81 \times 10^{-14}$

3. $LC = .000625 \times 10^{-4}$

4. $LC = 729 \times 10^{-10}$

5. L = 4 mH
   C = .003 µF

6. L = 40 mH
   C = 169 pF

7. $L = 239 \times 10^{-6}$ H
   $C = 106 \times 10^{-12}$ F

8. L = 200 µH
   C = 200 pF

EXPERIMENT

Experiment #1

RESONANCE

MATERIALS AND EQUIPMENT:

Audio generator
Oscilloscope
VTVM
RF choke 2.5 mH (Or similar LC product of approximately
Capacitor 2000 pF 5×10^{-12})

INFORMATION:

Resonance is the condition in an AC circuit when the inductive reactance (X_L) and the capacitive reactance (X_C) are equal.

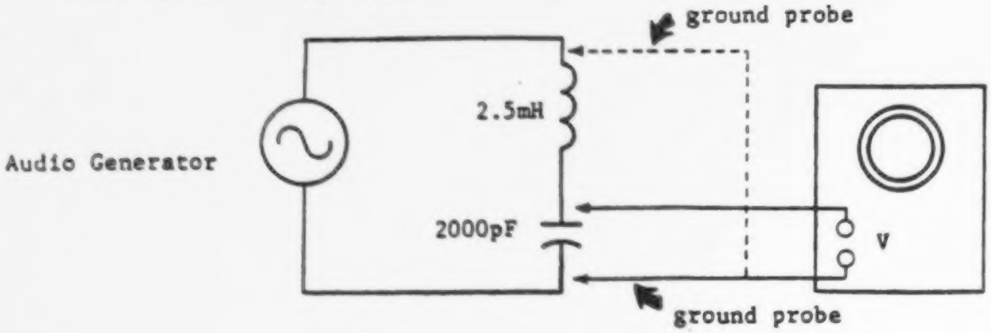
This experiment shall verify this by indirectly measuring the reactances at resonance, below, and above resonance. The measurement will be made by measuring the voltage drops across the reactances. The voltage drops are directly proportional to the reactances.

$$E_C = I_C X_C \qquad \text{and } E_L = I_L X_L$$

PROCEDURE:

1. Adjust the audio generator for an output between 1 V to 10 V, and adjust the oscilloscope to display this output at some reference level. Note: Since you will be measuring only the pk-pk amplitude of the AC voltage, you may want to remove the oscilloscope horizontal sweep so the display is only a thin vertical line.

2. Connect the following circuit.



EXPERIMENT

Experiment #2

VERIFICATION OF CALCULATED RESONANT FREQUENCY

MATERIALS AND EQUIPMENT:

Audio generator
Oscilloscope
8.5 H choke
.005 μF capacitor (LC product of substitutions should be less the 1×10^{-6} to keep the resonant frequency less than 150 kHz.)

PROCEDURE:

1. Compute the resonant frequency of the 8.5 H choke and .005 μF capacitor. Show formula and work.

Resonant frequency (fr) = __________

2. Verify your calculations by experimentally measuring the resonant frequency using the audio generator and oscilloscope. Refer to Experiment #1 for a review of the procedure. Record measured resonant frequency.

Measured f_r = ______________

3. Does the measured fr agree with your calculated fr in step 1? ____________ If not, why?

EXPERIMENT

Experiment #3

TUNING

MATERIALS AND EQUIPMENT:

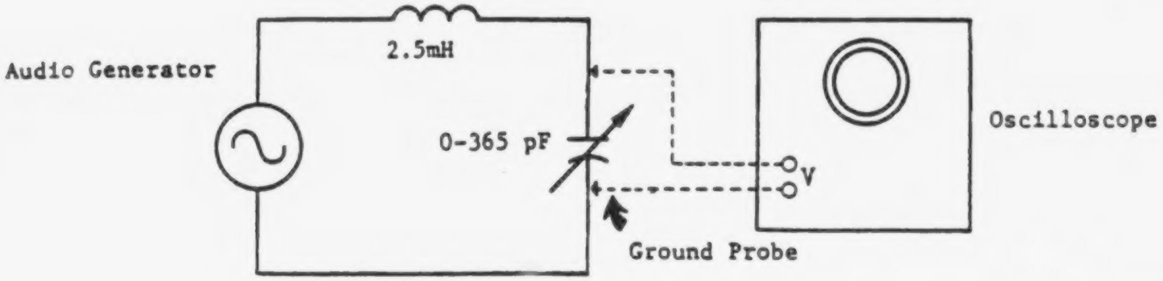
Audio generator
Oscilloscope
0-365 pF variable capacitor (Approximate values)
2.5 mH choke

INFORMATION:

Tuning means obtaining resonance at different frequencies by changing either the L or C in a resonant circuit.

PROCEDURE:

1. Connect the following resonant circuit.



2. Set the variable capacitor approximately in the middle of its range. (Plates half meshed.)

3. While measuring the voltage across the capacitor with the oscilloscope, adjust the audio generator frequency to the resonant frequency. (Indicated by maximum E_C.)

4. Vary the size of the capacitor and note effects on the applied frequency. As the capacitor is changed, the circuit is no longer resonant to the applied frequency, but is being made resonant to some other frequency.

Experiment #3 continued.

5. Measure the range of frequencies to which this circuit can be made resonant as follows.

a. Set the circuit for its highest resonant frequency. (Plates open all the way for the smallest capacitance.)

b. Adjust the audio generator to the resonant frequency. Read and record below.

f_1 Highest frequency ______________

f_2 Lowest frequency ______________

c. Set the circuit for its lowest resonant frequency (plates completely closed, largest capacitance). Measure the frequency and record above.

d. Compute the tuning range of this tuned circuit.

Tuning range = $f_1 - f_2$ = __________

PARALLEL RESONANT CIRCUITS

Lab Sheet #19

OBJECTIVES

To test and measure a parallel resonant circuit
To broaden the bandwidth in a parallel resonant circuit
To measure and plot the impedance curve for a parallel resonant circuit

INTRODUCTION

Parallel resonant circuits are sometimes called "anti-resonant" circuits or "band reject" circuits. This type of circuit exhibits characteristics opposite to a series resonant circuit. For example: The current(Itotal) is minimum since the impedance(Z) is maximum at resonance(Fr).

Many of the formulas for series resonance are used with parallel resonance. Here is a new one only for parallel resonant circuits:

$$Z = Q \times X_L$$

The above formula indicates that the impedance of a parallel resonant circuit is dependant upon: (1) the Q of the coil, and (2) the inductive reactance. Both of these can be very high, resulting in an extremely high circuit impedance good for blocking a specific frequency.

In both parallel and series resonant circuits, the bandwidth limits are defined as f1 and f2. "f1" and "f2" can be found where the CURRENT through R1 INCREASES 1.414 over the current value at resonance(Fr).

COMMON PARALLEL RESONANCE FORMULAS

NOTE: * indicates the formula is for both parallel and series resonance:

$$* \; Fr = \frac{1}{2\pi\sqrt{LC}} \qquad *BW = \frac{Fr}{Q} \qquad \begin{matrix} *f1 = Fr - \frac{1}{2}BW \\ *f2 = Fr + \frac{1}{2}BW \end{matrix}$$

$$* \; X_C = \frac{1}{2\pi FC} \qquad Qcircuit = \frac{Z}{X_L}$$

$$* \; X_L = 2\pi FL \qquad * \; Qcircuit = \frac{Fr}{BW}$$

"f1" and "f2" are the frequencies where Itotal is 1.414 times the value at resonance(Fr).

* Bandwidth(BW) = f2 - f1

* R1volts = Itotal x R1

$$**Z = \frac{(X_L)(X_C)}{(X_L - X_C)}$$

(** Non-resonance and resonance)

$$* \text{ Itotal} = \frac{\text{Vapplied(rms)}}{Z}$$

$$\text{Qtank circuit} = \frac{X_L}{R1 + L1_R}$$

(where $L1_R$ is the D.C. resistance of L1)

L1volts = Q x Vapplied

C1volts = Q x Vapplied

C1volts = L1volts

$$* \ Z = \frac{\text{Vapplied}}{\text{Itotal}}$$

NOTE: This does not include all the formulas that you may use, such as Ohms Law, Watts Law, and variations of those in the INTRODUCTION above. Refer to your text and notes for other formulas you may need.

PROJECT 1: Testing a Parallel Resonant RCL Circuit

MATERIALS

Inductor Board
Capacitor Board
3 scope leads
Resistors: 2k and 4.7k

INSTRUCTIONS

1. You will be using the adjustable (slug tuned) inductor (#6) on the Inductor Board as L1 in the circuit. The exact value of L1 is not known since it has an adjustable powdered iron core. The inductance can be varied from .3mH to .8mH. Leave it set at whichever value it is adjusted, but determine that value. You can use one of the previously learned methods of finding inductance: (1) the voltage divider method, or (2) the trigonometric formula.

Also, as a third way to find inductance, you could use a known value capacitor with the unknown inductor. Make a circuit with the two components and find the resonant frequency (Fr). With the resonant frequency, you can calculate inductance(L):

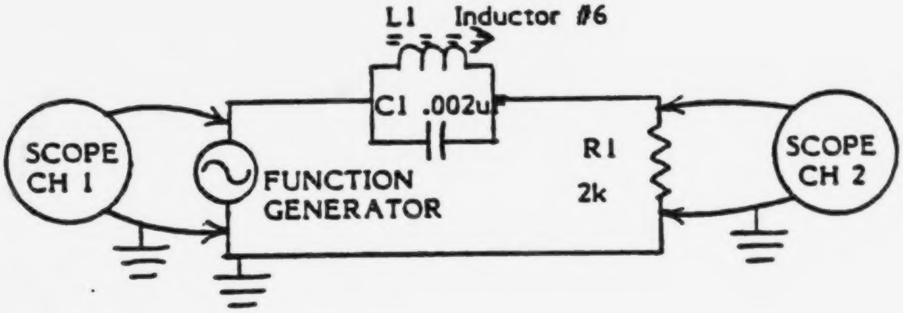
$$L = \frac{1}{4\pi^2 F^2 C} \qquad \text{(from Fr formula)}$$

Use any method you desire to determine the inductance of Inductor #6. Record your findings below, along with the D.C. resistance as measured with the ohmmeter.

L1:________mH

$L1_R$:________ohms

2. Connect the parallel resonant circuit below.



3. Calculate the following data for the STEP 2 circuit:
NOTE: * Indicates value at resonance(Fr).

	Formula	Calculated
a. *Resonant frequency(Fr):	$Fr = \frac{1}{2\pi\sqrt{LC}}$	__________Hz
b. *Inductive reactance(X_L):	$X_L = 2\pi FL$	________ohms
c. *Capacitive reactance(X_C):	$X_C = \frac{1}{2\pi FC}$	________ohms
d. *Tank "Q"(Qcircuit):	$Q = \frac{X_L}{R_L}$ (where R_L is the inductor internal resistance)	__________
e. *Circuit Bandwidth(BW):	$BW = \frac{Fr}{Q}$	__________Hz
f. Low frequency cutoff(f1):	$f1 = Fr - \frac{1}{2}BW$	__________Hz
g. High frequency cutoff(f2):	$f2 = Fr + \frac{1}{2}BW$	__________Hz

h. *Impedance(Z): $Z = Q \times X_L$ ________ohms

i. *Circuit current(Itotal): $\text{Itotal} = \frac{\text{Vapplied(rms)}}{Z + R1}$ ___________A

j. *Voltage across R1(R1volts): R1volts = Itotal x R1 ________v(rms)

4. Make necessary measurements to find the data below. NOTE: Some values must be calculated from other data. A formula is shown for these items.

Formula Measured

a. *Resonant frequency(Fr): __________Hz

b. *Voltage across R1(R1volts): ______v(rms)

c. *Circuit current(Itotal): $\text{Itotal} = \frac{\text{R1volts(rms)}}{R1}$ ___________A

d. *Impedance(Z): $Z = \frac{\text{Vapplied(rms)}}{\text{Itotal}}$ or $Q \times X_L$ ________ohms

e. Low frequency cutoff(f1): (See the note below) __________Hz

f. High frequency cutoff(f2): (See the note below) __________Hz

g. *Circuit Bandwidth(BW): BW = f2 - f1 __________Hz

h. *Circuit "Q"(Qcircuit): $Q = \frac{Fr}{BW}$ or $\frac{X_L}{R1 + R_L}$ ____________

NOTES FOR "e" AND "f" ABOVE:

NOTE FOR "h" ABOVE: Qcircuit = Qtank for parallel resonant circuits

"f1" and "f2" are the frequencies where the R1volts AMPLITUDE is 1.414 times the AMPLITUDE at Fr. To locate f1, do this:

(1) Set the function generator FREQUENCY to resonance(Fr).

(2) Set the function generator AMPLITUDE for 1 volt across R1 (Channel 2).

(3) Lower the function generator FREQUENCY until R1volts (Ch 2) is 1.414 volts.

(4) Make sure Vapplied (Ch 1) is still the same as it was at Fr.

(5) Using the frequency counter, measure the frequency out of the function generator. This is "f1".

Repeat the previous steps to find "f2" frequency above resonance(Fr).

5. Compare the measured data with the calculated data. Some items may not be very close, but that is all right. There are many factors which can introduce error in these Projects. One of these factors is stray capacity (another one might be your lab partner!). However, by now you are probably doing the procedures correctly and seeing that the theories seem to be true. The main purpose for doing these Projects is to develop skill in using the test equipment - - not to prove that the theories are right or wrong. Actually there are other formulas, procedures, and higher mathematics which produce more exact results, but they are not needed for our purpose here.

6. Make the necessary measurements to plot the IMPEDANCE(Z) CURVE for the STEP 2 circuit. Here is the procedure again (you did this in Lab Sheet #18):

a. Monitor Vapplied with channel 1, and R1volts with channel 2.

b. Set Vapplied to 2v p-p. (Any value is all right, as long as it is the same for each frequency.)

c. Starting at resonance, measure R1volts. From this measurement, calculate the current in the circuit. Next, calculate the impedance from the current and Vapplied. Record Z for that frequency.

d. Make similar measurements and calculations for the frequencies below and above resonance. Make sure that Vapplied is the same for each frequency (readjust AMPLITUDE only if necessary). Record Z for each frequency measured. Only measure enough frequencies to get a rough plot of the overall impedance curve.

7. Mark the Z points on the graph paper (Attachment 1). Choose and mark the values on your graph so that the curve fits the paper. Plot the curve by connecting the Z points. If there is one point way out of line, disregard it (probably it is an incorrect reading - - by your lab partner, of course). Label your curve, put your name on the page, and save it for later use.

SUMMARY

You should have observed these things:

Minimum signal voltage is across R1 at resonance.
Since impedance(Z) is maximum, current(Itotal) is minimum at resonance.

The resonant frequency(Fr) is blocked from passing through the circuit. However, frequencies greatly above and below Fr pass through the circuit.

PROJECT 2: Observing How Bandwidth is Broadened in a Parallel Resonant Circuit

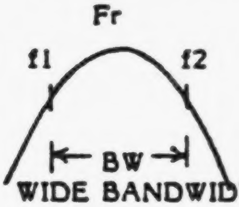
MATERIALS

Same as PROJECT 1 because you will use the same circuit, plus a 10kohm resistor.

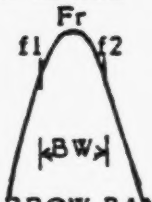
INTRODUCTION

In FM radios and TV circuits a wide bandwidth is required. This is done by installing a high value resistor in parallel with L1 and C1. This widens the bandwidth for better frequency response over a wide range of frequencies.

You will now make a wide bandpass resonant circuit.



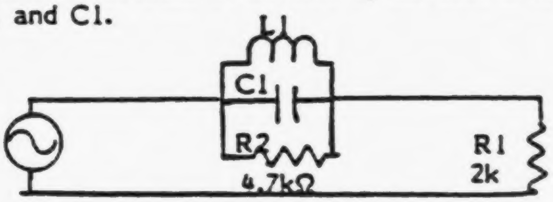
WIDE BANDWIDTH



NARROW BANDWIDTH

INSTRUCTIONS

1. Using the same circuit from PROJECT 1, connect a 4.7Kohm resistor in parallel with L1 and C1.



2. Determine the following for this circuit:

Fr: ________Hz

Itotal: ________mA

f1: ________Hz

f2: ________Hz

BW: ________Hz

Qcircuit: __________ (Find the Qcircuit by using measured bandwidth.)

3. Was the bandwidth wider than it was in PROJECT 1, STEP 3? YES/NO

Was the impedance higher or lower? HIGHER/LOWER

PROJECT 3: Plotting Frequency Response

INSTRUCTIONS

1. Make the necessary measurements to plot the frequency response curve for the broad bandwidth circuit in PROJECT 2. Plot the curve on the same graph paper used for PROJECT 1. Use a different color and label the curve. Be prepared to hand it in to your lab instructor.

NOTE: Plotting frequency response curves is a necessary skill that you should have developed by now. No further instructions will be given on how to "plot a frequency response curve".

PROJECT 4: Self Evaluation Quiz

INSTRUCTIONS

Complete the statement by crossing out the incorrect words.

1. At resonance X_L is equal to (R) (X_C) (Z) (L) (C) (Fr).

2. At resonance the circuit appears, or should appear, purely (reactive) (resistive) (lumpy).

3. Bandwidth is broad when there is a low value of (L and C) (Vapplied) (shunt resistor) (Q).

4. Q is highest when there is a high value of (X_L) (R) (Z) (L) (C) (BW) (shunt resistance).

5. A parallel resonant circuit has (high) (low) impedance at resonance.

6. Parallel resonant circuit impedance(Z) is high when there is a high value of (Q) (Itotal)) (Vapplied) (Fr) (L) (C) (X_L) (X_C).

7. In a parallel resonant circuit, a resistor in parallel with L1 and C1 will cause a decrease in the (Q) (Itotal) (R1volts) (BW) (Fr) (L).

8. Resonant frequencies (will) (will not) pass easily through a parallel resonant circuit.

9. To block only a narrow band of frequencies, out of the full spectrum of frequencies, you could use a (resistor) (capacitor) (parallel resonant) (series resonant) (band reject) (S.T.O.P.) circuit.

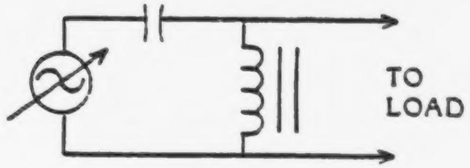
10. Resonant circuits are used in (televisions) (motors) (electric blankets).

INSTRUCTIONS

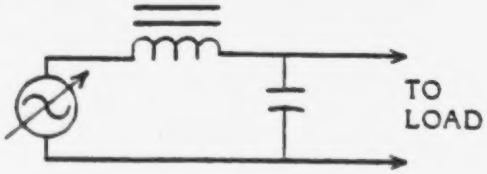
On Page 8 are shown different types of filter circuits. They are used to either pass or block narrow bands of frequencies out of the full spectrum of frequencies. They are merely applications of both SERIES and PARALLEL resonant circuits that you have studied. Chapter 28 (Grob) covers this subject in detail, but you should have enough information to answer these questions.

Study the different circuits below and match each to a functional description in questions 11 through 14.

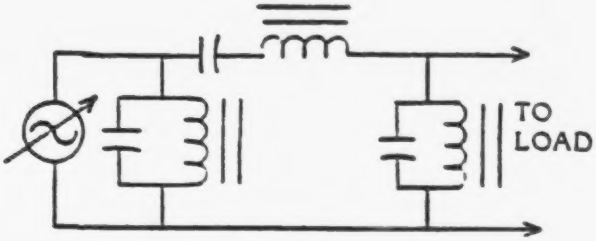
ALL CIRCUITS BELOW ARE TUNED TO THE SAME RESONANT FREQUENCY.
A VERY WIDE RANGE OF FREQUENCIES IS APPLIED TO EACH CIRCUIT.



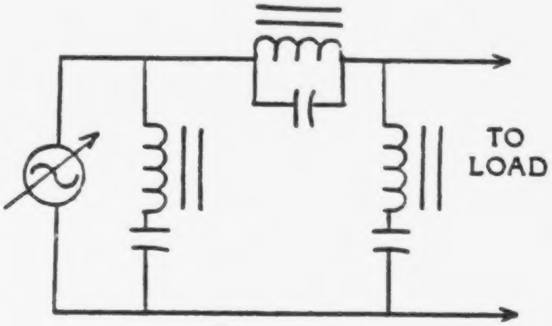
A.



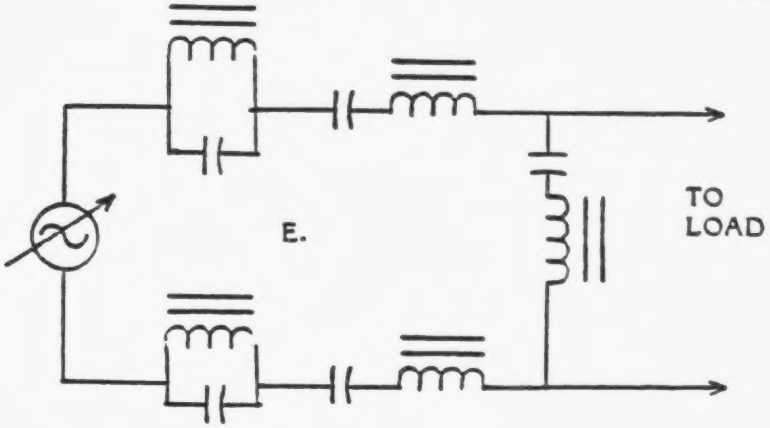
B.



C.



D.



E.

11. Circuit ____ will pass only a desired band of frequencies, on or near resonance. All other frequencies will be blocked from reaching the load.

12. Circuit ____ is used to pass high frequencies and attenuate low frequencies.

13. Circuit ____ is a filter designed to block frequencies on or near reasonance. It passes all other frequencies to the load. It might be used in a radio antenna, if there is an interfering local station.

14. Circuit ____ is designed to pass only frequencies below a desired value. It attenuates high frequencies. This filter might be used to reduce tape "hiss" in a cassette recorder.

Answers to Self Evaluation:

1. X_C
2. resistive
3. Q
4. shunt resistor
5. high
6. Q, L, X_L,X_C
7. Q
8. will not
9. parallel resonant; band reject
10. televisions
11. C
12. A
13. D
14. B

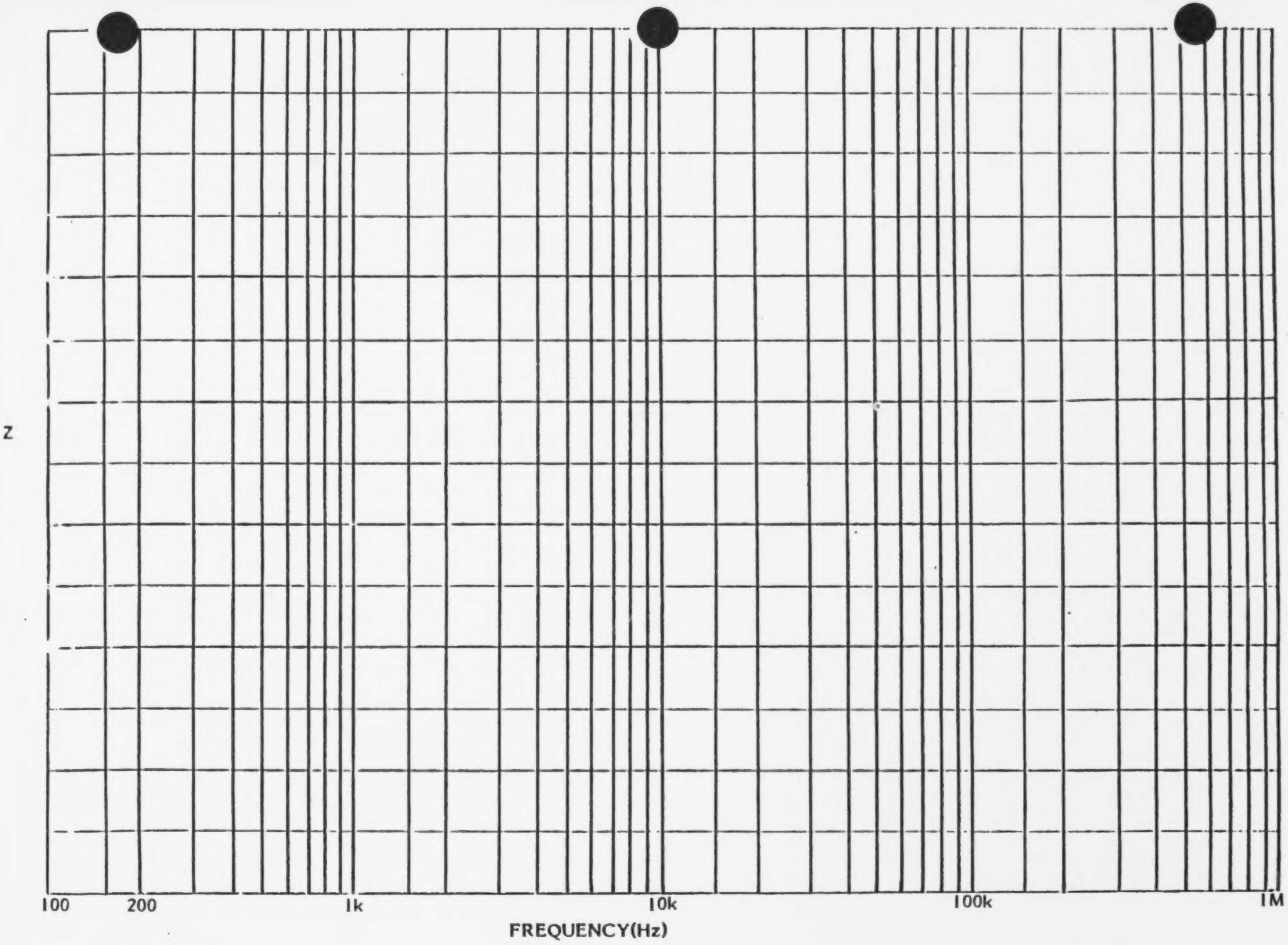
Your score:_______

How did you do?

Really good, for a subject this hard.

So-so. Maybe my biorhythms are down.

I'm considering being a basket weaver instead of an electronics technician.



Attachment I

SERIES RESONANT CIRCUITS

Lab Sheet #18

OBJECTIVES

To test and measure the characteristics of a series resonant circuit
To measure the bandwidth of a series resonant circuit
To plot the impedance versus frequency curve for a series resonant circuit

FORWARD

Resonant circuits are extremely important to all types of communications equipment. They are used for TUNING IN desired signals and for TUNING OUT undesired ones. In the following Projects you will observe series resonant circuits operate as tuned circuits. You will be experimenting with parallel resonant circuits in the next Lab Sheet. Each circuit has unique characteristics which are valuable for radio communications equipment.

By now you should be quite familiar with the test equipment and the techniques for setting up operating circuits. These instructions, therefore, will be intentionally brief. You should be developing your self-reliance and resourcefulness for your future job in electronics. Refer to your textbook as you would refer to a technical manual. Do research as necessary to fully understand the principles involved. This does not mean that you cannot ask for help. However, it does mean you should exhaust all your own resources before you seek help. You can gain greater confidence in yourself as a technician after you see how much you really do know.

See the summary following each Project for key concepts that you should have observed. For maximum learning, do not refer to the summary until you have completed the Project. You may wish to go back and repeat some Projects.

PROJECT 1: Connecting and Testing Series Resistance, Capacitor, and Inductor (RCL) Resonant Circuits

INTRODUCTION

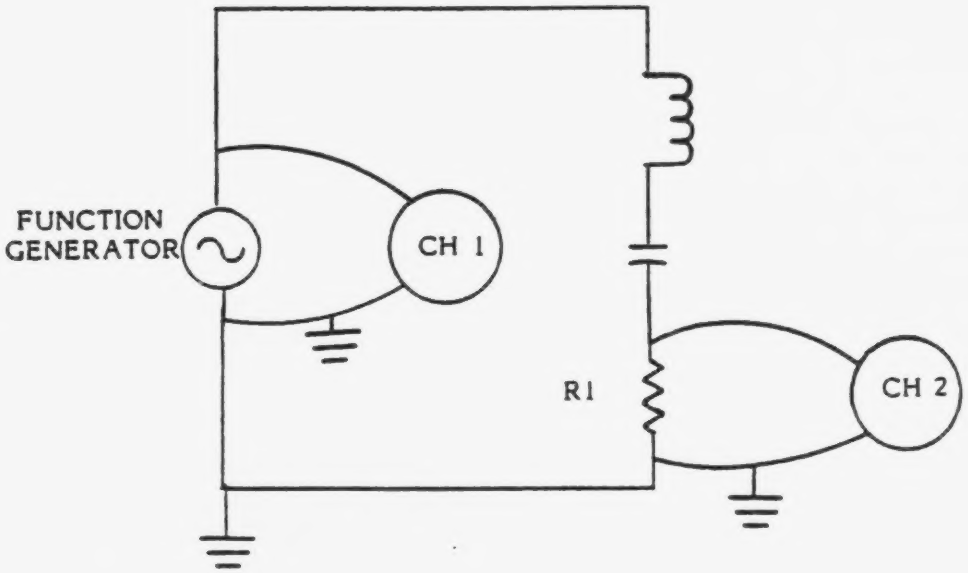
In an RCL series circuit, the inductive reactance (X_L) varies directly with frequency. Capacitive reactance (X_C) varies inversely with frequency. The point where X_L equals X_C is the resonant frequency(Fr). A circuit with a resistor, capacitor, and inductor(RCL) is resonant to only one frequency. Since X_L and X_C cancel each other in an RCL series resonant circuit, only resistance(R) remains to limit the current. The total circuit resistance (at resonance) includes the resistor AND the inductor internal resistance. Therefore, at resonance only a narrow range of frequencies are passed through the circuit. These frequencies, at and near the resonsnt frequency, pass easily through the circuit while all other frequencies are blocked.

To test a series resonant circuit, you will be doing this (study it before attempting to do it):

a. Connect the scope (Channel 2) across R1 to monitor the VOLTAGE. This will indicate how much current is passing through the circuit. From this you can calculate the circuit IMPEDANCE AT ANY FREQUENCY. The frequency which produces the highest signal voltage across R1 is the RESONANT FREQUENCY(Fr), since the circuit impedance is minimum.

b. Connect scope (Channel 1) to monitor the applied input signal to insure that the voltage is the same for each frequency. Readjust the function generator AMPLITUDE as necessary to maintain the desired applied voltage at all times. Only the FREQUENCY should be changed in this test. Only adjust the Function Generator AMPLITUDE to maintain the input signal voltage constant.

c. Change the Function Generator FREQUENCY to the different frequencies specified, and observe the effect on the circuit current. A maximum current (indicated by a maximum signal amplitude on channel 2) occurs at resonance(Fr). You will have to look for the resonant frequency between 1KHz and 1MHz. "Rock" the frequency dial on the Function Generator back and forth near resonance to find the highest possible voltage across R1 and the exact resonant frequency.



FORMULAS FOR SERIES RESONANT CIRCUITS:

NOTE: *Indicates that the formula is the same for a parallel resonant circuit.

$$Fr = \frac{1}{2\pi\sqrt{L\,C}} \qquad BW = \frac{Fr}{Q}$$

$$f1 = Fr - \tfrac{1}{2}BW$$

$$f2 = Fr + \tfrac{1}{2}BW$$

* $X_C = \dfrac{1}{2\pi F C}$

Qcircuit $= \dfrac{V_{L1}}{\text{Vapplied}}$

* $X_L = 2\pi F L$

* Qcircuit $= \dfrac{Fr}{BW}$

f1 and f2= Frequency where Itotal is 70.7% of the value at resonance(Fr)

Qcircuit $= \dfrac{X_L}{R1 + L1_R}$

* Bandwidth(BW) = f2 - f1

C1volts = Itotal x X_C

C1volts = Q x Vapplied

* R1volts = Itotal x R1

L1volts = Itotal x X_L

$Z = R1 + L1_R$

L1volts = Q x Vapplied

* $Z = \dfrac{\text{Vapplied}}{\text{Itotal}}$

* Itotal $= \dfrac{\text{Vapplied(rms)}}{Z}$

NOTE: This does not include all the formulas that you may use, such as Ohms law, Watts law, and variations of the above. Refer to your text and notes for other formulas that you may need.

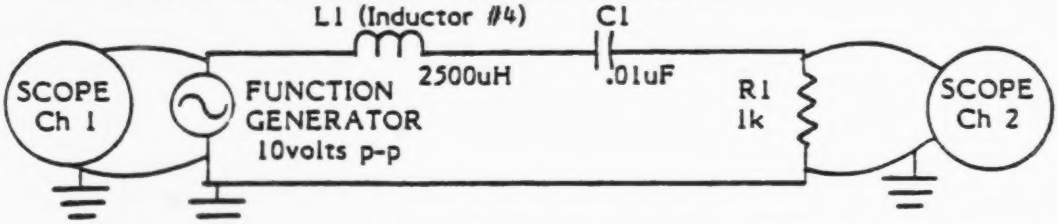
MATERIALS

Inductor Board (check out)
Capacitor Board (check out)
Function Generator
Oscilloscope
Frequency Counter
DMM
3 scope leads
Resistors: 220 ohms, 470 ohms, 1k

INSTRUCTIONS

1. Measure the D.C. resistance of Inductor #4 (2500uH) with an ohmmeter.
Record: $L1_R$:__________ohms.

2. Connect the series RCL resonant circuit below.



3. Calculate the following for the STEP 2 circuit. Show the formula used.
NOTE: All values are calculated at the resonant frequency.

Formula Calculated

a. Resonant frequency(Fr): ____________Hz

b. Impedance(Z): __________ohms

c. Circuit current(Itotal): ____________mA

d. Voltage across R1(R1volts): _________v(rms)

e. Inductive reactance(X_L): __________ohms.

f. Voltage across L1(L1volts): _________v(rms)

g. Capacitive reactance(X_C): __________ohms.

h. Voltage across C1(C1volts): _________v(rms)

4. Test the circuit in STEP 2 and verify the calculations with the test equipment. Reconnect the circuit to: (1) avoid common ground problems, and (2) make all required measurements. Record below and compare with calculated values in STEP 3. Be prepared to explain any differences in values. NOTE: Some values must be found indirectly using other measurements and calculations. (Examples: Itotal, inductive reactance, capacitive reactance, and impedance).

Measured

a. Resonant frequency(Fr): ____________Hz

b. Voltage across R1(R1volts): __________v(rms)

c. Circuit current(Itotal): _________mA(rms)

d. Impedance(Z): ____________ohms

e. Voltage across L1(L1volts): __________v(rms)

f. Inductive reactance(X_L): __________ohms

g. Voltage across C1(C1volts): ____________v(rms)

h. Capacitive reactance(X_c): ____________ohms

SUMMARY

You should have observed these things:

Itotal, and therefore R1volts, are maximum at RESONANCE(Fr).

IMPEDANCE(Z) is MINIMUM at resonance and is equal to the total resistance in the circuit. The total resistance consists of: (1) R1 and (2) the inductor internal resistance. That is, $Z = R1 + L1_R$. Circuit current(Itotal) was limited primarily by R1. If R1 is 10 times the value of $L1_R$, we usually disregard $L1_R$ when doing calculations.

Voltage across C1 and L1 are maximum at resonance. Each voltage is 90 degrees out of phase with the applied voltage. This can be seen on the scope by aligning the L1volts or C1volts signal (Channel 2) slightly under the Vapplied signal on Channel 1. L1volts and C1volts can be higher than Vapplied.

C1 and L1 voltages are approximately equal. L1 voltage is slightly higher due to the internal resistance in L1 ($L1_R$).

Formulas and procedures you may have used to find data in STEP 4:

Step

4a. $Fr = \frac{1}{2\pi\sqrt{LC}}$ Measured. Maximum R1volts at Fr. Actual Fr is probably lower due to stray capacity.

4b. Measured with scope.

4c. $\text{Itotal} = \frac{\text{R1volts}}{\text{R1}}$

4d. $Z = \frac{\text{Vapplied(rms)}}{\text{Itotal}}$

4e. L1volts: Measured after the circuit was reconnected to eliminate common ground problems.

4f. $X_L = \frac{\text{L1volts(rms)}}{\text{Itotal}}$ Notice that L1volts is 90 degrees out of phase with Vapplied at Fr.

4g. C1volts: Measured, after the circuit was reconnected to eliminate ground problems.

4h. $X_c = \dfrac{\text{C1volts(rms)}}{\text{Itotal}}$ Notice C1volts is 90 degrees out of phase with Vapplied at Fr.

PROJECT 2: Testing a Series RCL Resonant Circuit for Bandwidth

INTRODUCTION

In this Project, you will measure the bandwidth of frequencies which pass through this series resonant circuit. The circuit will be similar to the one in PROJECT 1 except that different component values will be used. When this circuit is at resonance the impedance is quite low. This may cause the function generator to load-down and the amplitude to drop. You may need to readjust the Function Generator AMPLITUDE control to maintain the required Vapplied at the different frequencies.

You will be given minimum instructions. See how well you can test this circuit without help.

INSTRUCTIONS

1. Draw a series RCL resonant circuit using the components indicated below. Show the function generator and both scope channel connection points.

C1: .002uF (Check out from tool room. Return it when finished.)
L1: Inductor #4 on the Inductor Board (2.5mH)
R1: 1kohm
Volts applied: 3v(p-p)

2. Calculate the following for the STEP 1 circuit. Show the formula that you used.

NOTE: * Indicates value at resonant frequency(Fr).

Formula Calculated

a. *Resonant frequency(Fr): ____________Hz

b. *Impedance(Z): __________ohms

c. *Circuit current(Itotal): ____________A

d. *Voltage across R1(R1volts): _________v(rms)

e. *Inductive reactance(X_L): ________ohms

f. *Voltage across L1(L1volts): ________v(rms)

g. *Capacitive reactance(X_C): ________ohms

h. *Voltage across C1(C1volts): ________v(rms)

i. *Inductor L1 "Q": ______________

j. *Circuit "Q": ______________

k. *Circuit Bandwidth(BW): ____________Hz

l. Low frequency cutoff(f1): ____________Hz

m. High frequency cutoff(f2): ____________Hz

3. Connect the circuit in STEP 1 and verify the STEP 2 calculations with the test equipment. Record your measurements below and compare the calculated with the measured values. You should be able to explain any differences in values.

Formula Measured

a. *Resonant frequency(Fr): ____________Hz

b. *Voltage across R1(R1volts): ________v(rms)

c. *Circuit current(Itotal): ____________A

d. *Impedance(Z): ________ohms

e. Low frequency cutoff(f1): ____________Hz

f. High frequency cutoff(f2): ____________Hz

g. *Circuit Bandwidth(BW): ____________Hz

h. *Circuit "Q"(Qcircuit): ______________

SUMMARY

You should have observed these things:

The maximum signal voltage is across R1 at resonance. Since impedance(Z) is minimum, current(I) is maximum at resonance.

At resonance, the voltage across R1(R1volts) is in phase with the applied voltage(Vapplied).

(continued next page)

Below resonance, the voltage across the resistor (R1volts) LEADS the applied voltage. Since C1 has more reactance than L1, the current is "capacitive". (Remember: "ELI the ICE man".) R1volts LAGS the applied voltage above resonance, where the circuit is "inductive".

Frequencies each side of the resonant frequency(Fr) pass through the circuit, but at reduced amplitude. The frequencies where the amplitude is 70.7% of the Fr amplitude are f1 and f2. Frequencies f1 and f2 define the bandwidth of the circuit.

Your measured values may have varied 30% or 40% from calculated values due to other variables such as stray capacitance and component tolerance.

The below formulas are some which could be used to determine the values in the steps indicated.

Step	NOTES
3a. $Fr = \dfrac{1}{2\pi\sqrt{L\,C}}$	Fr is lower than that which you calculated, due to stray capacitance, and perhaps inductor value is low.
3b. R1volts: Measured.	Maximum at resonance. Approximately 1v(rms).
3c. $Itotal = \dfrac{R1volts}{R1}$	Approximately 1mA.
3d. $Z = \dfrac{Vapplied}{Itotal}$	Approximately 1k ohm.

3e. "f1" is the frequency below Fr where the amplitude is 70.7% of the amplitude at Fr. Hint: Set Fr amplitude at 1 volt. Lower the frequency until the same signal is .707 volts. Measure frequency f1. To calculate: f1 = Fr - BW/2. Approximately 35kHz to 45kHz.

3f. f2 is the frequency above Fr where amplitude is 70.7% of amplitude at Fr. To calculate: f2 = Fr + BW/2. Approximately 65kHz to 75kHz.

3g. Bandwidth(BW) = f2 - f1. To calculate: $BW = \dfrac{Fr}{Q}$. (62k to 65kHz.)

3h. $\text{Qcircuit} = \frac{Fr}{BW}$ Approximately 1 to 4. This is low, primarily due to R1. We need R1 to be a load on the function generator so that it does not load down.

also $\text{Qcircuit} = \frac{\text{C1volts (or L1volts)}}{\text{Vapplied}}$

3i. $L1_Q = \frac{X_L}{L1_R}$ Varies with each inductor. Approximately 1000 if R1 is not in the circuit.

3j. L1volts: Measured after the circuit is reconnected so that common grounds are not a problem. L1 voltage may be higher than the applied voltage. Approximately 5 to 10 volts p-p.

3k. $X_L = \frac{\text{L1volts(rms)}}{\text{Itotal}}$ Approximately 1500 ohms

3l. C1volts: Measured approximately 5 to 10 volts p-p. C1 has to be reconnected to eliminate ground problems. Also, whenever C1 value is small, connecting a scope lead across it may change the resonant frequency. This is due to the stray capacitance of the scope coax cable. You must retune to find Fr. Whenever you change anything in a resonant circuit, it is good practice to retune for Fr.

3m. $X_C = \frac{\text{C1volts(rms)}}{\text{Itotal}}$ Approximately 1500 ohms

3n. The voltage across both C1 and L1 should be 0 volts. It was not. Do you know why? (L1 has some internal resistance.)

PROJECT 3: A Study of Bandwidth and Impedance in a Series Resonant Circuit

INTRODUCTION

Resonant circuits are widely used in radio frequency circuits to pass a desired frequency and block all others. You probably observed that the frequencies on either side of Fr also were passed, but with less amplitude. Only frequencies greatly above and below Fr were completely blocked. The frequencies 70.0% down in amplitude are defined as the f1 and f2. We accept these frequencies as the lower and upper limits of the BANDWIDTH. The bandwidth of a circuit is dependent upon X_L and $R1 + L1_R$.

In this Project you will vary R1 and observe the effect on bandwidth. You will see this clearly by making the measurements of Itotal at various frequencies and graphing the impedance(Z). You will do this using different values for R1, and graphing the impedance versus frequency curves. You are encouraged to do this with minimal instructions.

INSTRUCTIONS

1. Use the same series resonant circuit as in PROJECT 2 with R1 = 220 ohms, C1 = .01uF, L1 = Inductor #4 (2.5mH). Connect it as before so that you can determine the current flow at any frequency. Insure that Vapplied remains constant for each frequency applied.

2. Make the necessary measurements to plot the impedance(Z) curve for the circuit. Use this procedure:

a. Monitor Vapplied with channel 1, and R1volts with channel 2.

b. Set Vapplied to 2v p-p. (Any value is all right, as long as it is the same for each frequency.)

c. Find resonance and measure R1volts. From this measurement, calculate the current in the circuit. Next, calculate the impedance from the current and Vapplied. Record impedance(Z) for the resonant frequency.

d. Make similar measurements and calculations for the frequencies below and above resonance. Make sure Vapplied is the same for each frequency (readjust AMPLITUDE only if necessary). Record Z for each frequency measured. Only measure enough frequencies to get a rough plot of the overall impedance curve.

e. Plot the Z points on the graph paper (Attachment 1). Choose and mark the values on your graph so that the curve fits the paper. Sketch in the curve by connecting the Z points.

3. Change R1 to 1kohms. Repeat measurements and plot Z in a different color.

4. Label your graph and mark the f1 and f2 points for each Z curve. Put your name on the page and be prepared to hand it in to your instructor.

SUMMARY

You should have observed these things:

a. A series resonant RCL circuit has minimum impedance at resonance.

b. R1 value affects the circuit Q and the bandwidth.

c. Plotted curves for impedance versus frequency show narrower bandwidths when R1 value is lowest.

You should be able to test and measure a series resonant circuit and to plot the impedance versus frequency curve.

PROJECT 4: Self Evaluation

INSTRUCTIONS

Complete the statement by crossing out the incorrect words.

1. At series resonance, (current) (impedance) (X_L) is/are maximum.

2. At series resonance, (current) (impedance) (X_L) is/are minimum.

3. At resonance, X_L is equal to (R) (X_c) (Z) (L) (C) (Fr).

4. At resonance, the circuit appears, or should appear, purely (reactive) (resistive) (lumpy).

5. Bandwidth is narrowest when (L and C) (Q) (X_L) (R) is/are high.

6. "Q" is highest when (X_L) (R) (Z) (L) is/are high.

7. Frequencies f1 and f2 are called "the half-power points" since (voltage) (current) is/are down 70.7% from the value at resonance(Fr).

8. In a series resonant circuit, the voltage across L1 or C1 is high when (R) (Z) (X_L) (X_c) is/are high.

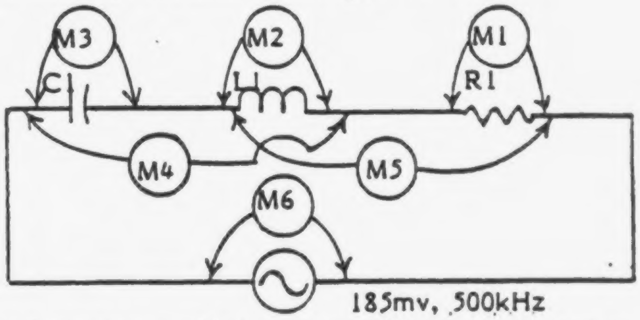
9. Bandwidth is narrowest in a resonant circuit when L1 internal resistance is (high) (low) (1500 ohms) (equal to R1).

10. Resonant frequencies will pass easily through a (series) (parallel) resonant circuit.

11. In a series resonant circuit, the voltage across L1 or C1 is high when (R) (X_L) (X_c) (frequency) is/are low.

Use the schematic below for questions 12 through 15.

C1: 424pF
L1: 239uH
R1: 8.6ohms



12. If R1 is decreased in value, which meters will read a higher value?

M1 M2 M3 M4 M5 M6

13. If C1 is changed to 212pF, which of these will increase?

X_L X_c R1volts Itotal Z Phase angle

14. If the frequency is changed to 1000kHz, which of these will increase?

X_L X_c R1volts Itotal Z Phase angle

15. If R1 value is increased, which of these will increase?

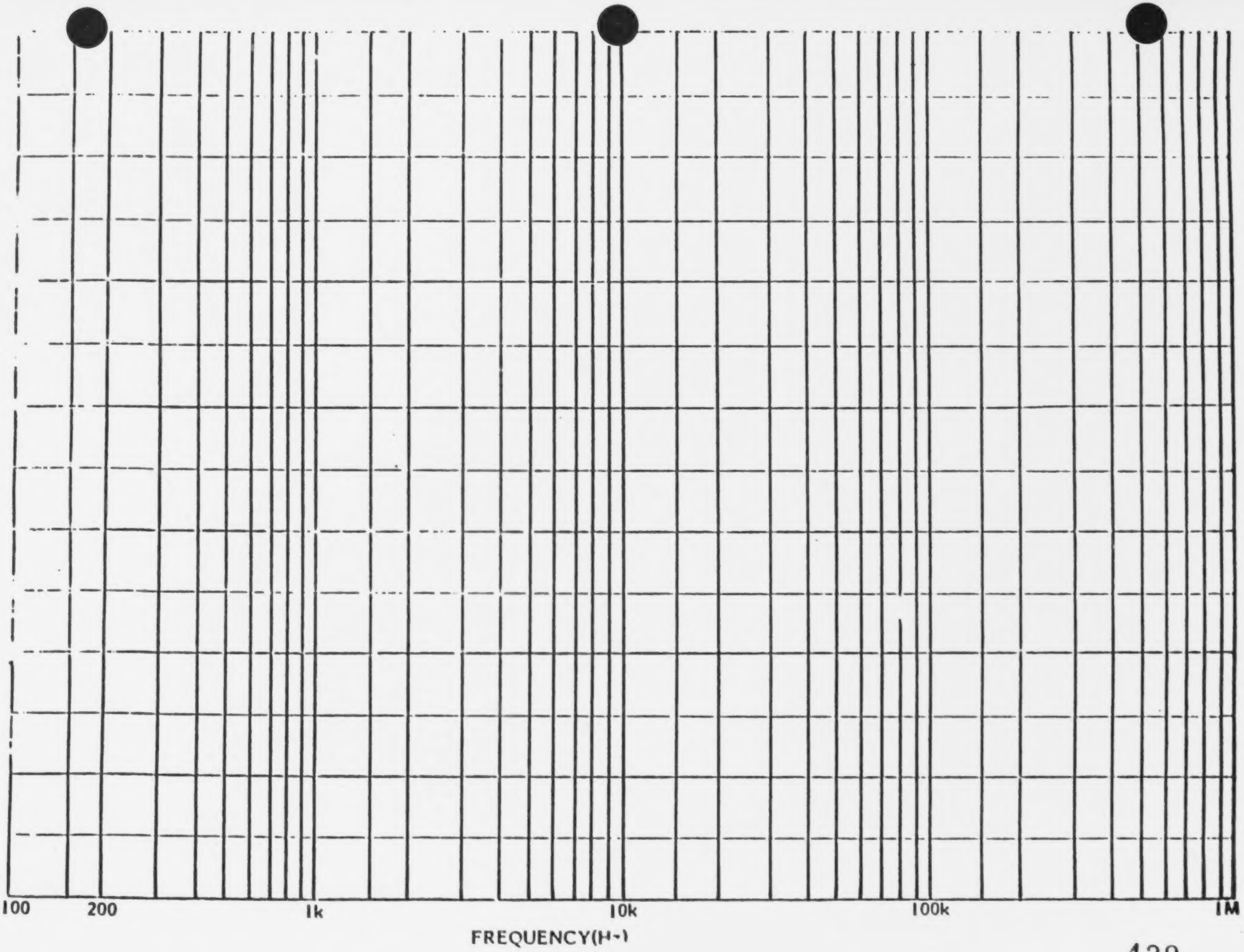
BW Qcircuit Z X_L X_c price

Answers to Self Evaluation:

1. current
2. impedance
3. X_c
4. resistive
5. Q, L
6. X_L, L
7. voltage, current
8. X_L, X_c
9. low
10. high
11. R
12. M2, M3, M5
13. X_c, Z, phase angle
14. X_L, Z, phase angle
15. BW, Z

Your score:________

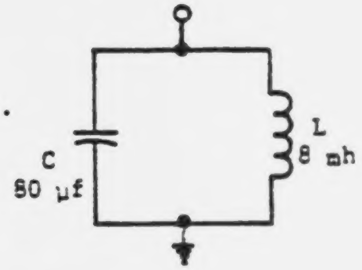
How did you do? Fantastic. Remarkably well. Could be better.



Attachment I

Self Test

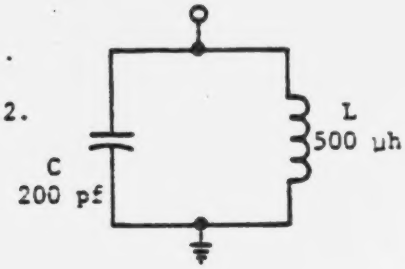
1.



What is the resonant frequency?

____

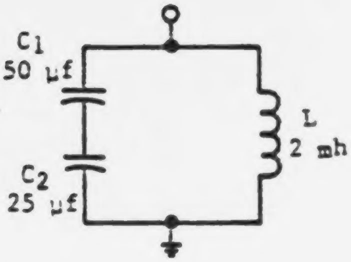
2.


C
200 pf
L
500 µh

What is the resonant frequency?

____

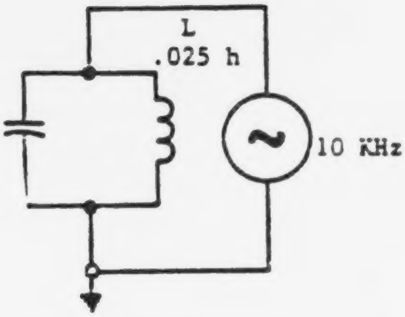
3.


C1
50 µf
C2
25 µf
L
2 mh

What is the resonant frequency?

____

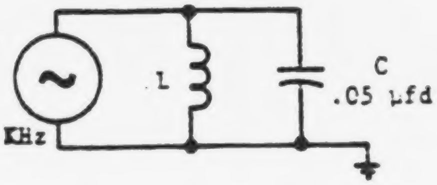
4.


L
.025 h
10 KHz

What value of C is needed for resonance?

____

5.


5 KHz
L
C
.05 µfd

What value of L is needed for resonance?

____

6. List at least 4 characteristics of a parallel resonant circuit.

Self Test

Directions Answer the following questions.

1. Resonance is the condition when:

   A. $X_C < X_L$ B. $X_C > X_L$

   C. $X_C \approx X_L$ D. $X_C = X_L$

2. If the capacitance in a resonant circuit is increased, the resonant frequency:

   A. Increases B. Decreases

   C. Remains the same D. None of these

3. In a tuning circuit, if the plates of the cpacitor are completely open, the circuit will be resonant at the:

   A. lower end of the tuning range
   B. Upper end of the tuning band
   C. Open and not resonate to any frequency
   D. None of the above

4. What is the resonant frequency of a capacitor—inductor combination with an LC product of 576×10^{-12}?

5. What is the resonant frequency of a 500 pF capacitor in series with a 2 mH coil?

Self Test continued.

6. If the C in a circuit is doubled and the L is reduced to one-half, what happens to the resonant frequency?

   A. Increases B. Decreases

   C. Remains the same D. None of these

7. What is the tuning range of a 5-500 μF variable capacitor with a 5 μH coil? What are the upper and lower frequency limits?

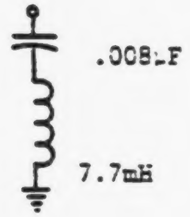
8. What size inductor is required to resonate with a 365 pF capacitor at 550 kHz?

9. What size capacitor is required to resonate with an 8.5 H choke at 120 Hz?

Self Test

Directions Answer the following questions.

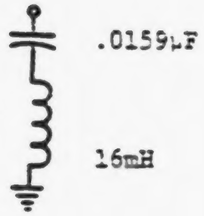
1.



What is the resonant frequency?

____

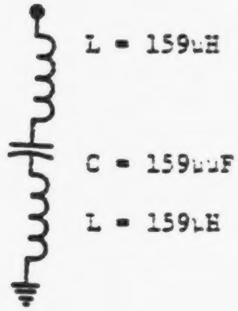
2.


.0159μF
16mH

What is the resonant frequency?

____

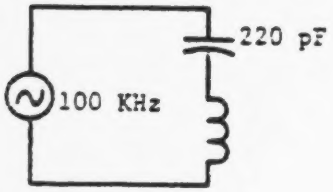
3.


L = 159μH
C = 159μμF
L = 159μH

What is the resonant frequency?

____

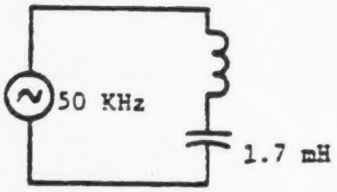
4.


220 pF
100 KHz

What value of L is necessary for resonance?

____

5.



What value of C is necessary for resonance?

____

Self Test (cont'd)

6. A circuit is made up of an inductor, capacitor and resistor connected in series. The resistor is 680Ω, and the d-c resistance of the inductor as measured by an ohmmeter is 125Ω. The generator has an applied voltage of 5 volts at fo. Find the following:

   a. I_T

   b. Z_T

   c. V_R

   d. Phase angle

   e. power supplied to the circuit

7. List at least 4 characteristics of a series resonant circuit.

   a.

   b.

   c.

   d.

Self Test

Directions

Do the following problems.

1. Q is the quality of a tuned circuit and is defined as the ratio of which of the following at resonance?

   A. X_L to X_C
   B. E_L to E_C
   C. X_L to R
   D. I_C to R

2. The response of the two frequencies which set the limits of the bandwidth, have what percentage of the response of the resonant frequency?

   A. x 86.6%
   B. x 70.7%
   C. x 50%
   D. x 25%

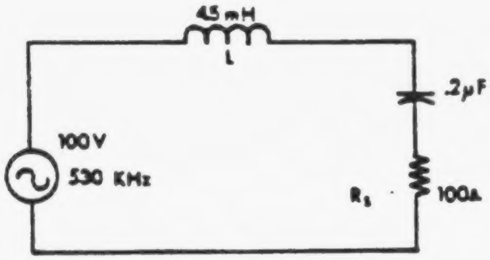
3. If the Q of a resonant circuit is increased, the bandwidth of the circuit will:

   A. increase
   B. decrease
   C. remain the same
   D. none of these

4. If the Q of a series resonant circuit is decreased, what happens to the voltage drops across the inductive and capacitance reactances?

   A. increase
   B. decrease
   C. remains the same
   D. none of these

5. What is the Q of the following circuit at resonance?



SELF TEST (cont'd)

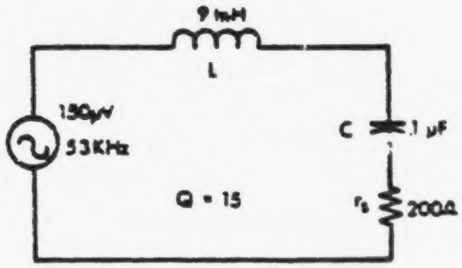
6. Which of the following LC combinations, that have the same LC product, has the highest Q?

   A. 4 mH coil and 100 μF capacitor
   B. 2 mH coil and 200 μF capacitor
   C. 40 mH coil and 10 μF capacitor
   D. 20 mH coil and 20 μF capacitor

7. When a parallel resonant circuit is damped with a shunt resistor, the circuit:

   A. bandwidth increases
   B. bandwidth decreases
   C. Q increases
   D. Q decreases
   E. A and C
   F. A and D
   G. B and C
   H. B and D

8. What would be the voltage drop (E_C) across the capacitor in the following circuit at resonance?



9. What is the bandwidth of the circuit in Question 8?

UNIT EXAM

Circuits Containing R, C, and L

IMPORTANT:

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question. There is only one correct answer for each question.

1. Impedance represents the total "AC resistance" of a circuit containing resistance, capacitance, and inductance. (T - F)

2. The letter symbol for impedance is I. (T - F)

3. If the impedance of a circuit is minimum, the circuit current will be maximum. (T - F)

4. Impedance is measured in the base unit ohms. (T - F)

5. The formula for computing impedance in a series RL circuit is $z = \sqrt{R^2 + X^2}$ (T - F)

6. In an RCL circuit a condition can exist where $X_c = X_L$. This condition is called reactance. (T - F)

7. The letter symbol for resonant frequency is "f_r". (T - F)

8. A filter circuit that can pass one frequency and reject neighboring frequencies has poor selectivity. (T - F)

9. A circuit designed to pass some frequencies and block others is called an integrated circuit. (T - F)

10. Filter circuits can be divided into two broad categories: "frequency selective", or " power supply" filters". (T - F)

11. Filter circuits utilize only capacitors and resistors to provide frequency selective networks. (T - F)

12. Series resonant circuits provide maximum impedance at resonance. (T - F)

13. One characteristic of a parallel resonant circuit is that it allows minimum current flow when operating at its resonant frequency. (T - F)

14. A high-pass filter is designed to attenuate high frequencies. (T - F)

15. The "f_r" of a tank circuit can be found by utilizing the formula $f_r = \frac{1}{2\pi\sqrt{LC}}$ (T - F)

16. The total opposition to current flow in a circuit that contains resistance, capacitive reactance, and inductive reactance is described as:
a. impedance b. reactance c. resistance d. resonance

17. The letter symbol for impedance is:
a. X b. I c. Z d. f_r

18. The basic unit of measurement for impedance is the:
a. farad b. ohm c. henry d. hertz

19. To solve for the impedance of a series RC circuit you should apply which of the following formulas:
a. $Z = \sqrt{R^2 + X^2_C}$ b. $Z = \sqrt{R^2 \cdot X^2}$
c. $Z = \sqrt{R^2 + (X_C - X_L)^2}$ d. either a or c

20. Impedance represents a force ________________ the flow of current and is analogous to ________________ in a D-C circuit.
a. opposing, resistance b. opposing, conductance
c. aiding, resistance d. aiding, conductance

21. In a series LC circuit at resonance:
a. maximum current flows in the LC circuit b. minimum current flows in the LC circuit c. the current leads the voltage at the source d. the current lags the voltage at the source.

22. In a parallel LC circuit the impedance at resonance is:
a. very low b. very high c. the same as when off-resonance d. equal to the impedance of a series circuit

23. At resonance in a series RCL circuit Z has its ________________ value, and is equal to ________________.
a. minimum, R. b. maximum, R. c. maximum, R.
d. minimum, X.

24. As frequency increases in an LC circuit, inductive reactance ______________ and capacitive reactance ______________.

a. increases, increases b. increases, decreases
c. decreases, increases d. decreases, decreases

25. There will always be a frequency in a RCL circuit, called the ______________ frequency, at which ______________.

a. natural, $X_L = X_C$ b. oscillating, $R = 0$
c. resonant, $X_L = X_C$ d. reactance, $X = 0$

26. At resonance, the impedance is very ______________ and the current is very ______________ in a parallel RCL circuit.

a. large, large b. large, small c. small, large
d. small, small

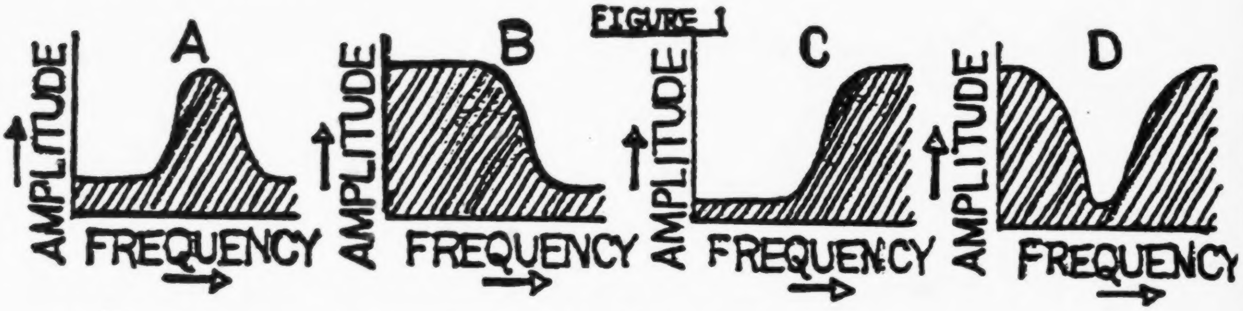
27. The behavior of a parallel resonant RCL circuit is esentially ______________ to that of a series resonant RCL circuit.

a. similar b. opposite c. unrelated d. identical

28. A parallel RCL circuit behaves inductively ______________ and capacitively ______________.

a. at D-C, at resonance b. at resonance, at D-C
c. above resonance, below resonance d. below resonance, above resonance.

FIGURE 1



29. Identify the response curve (in figure 1) for a low-pass filter.
a. curve A b. curve B c. curve C d. curve D

30. Locate the response curve from figure 1 which represents a band-reject filter.
a. curve A b. curve B c. curve C d. curve D

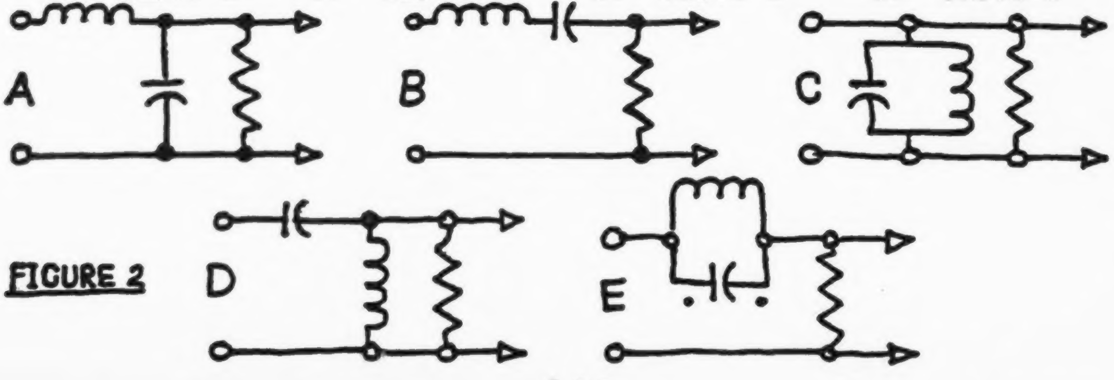
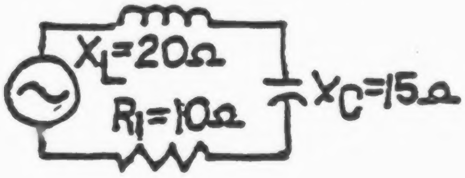


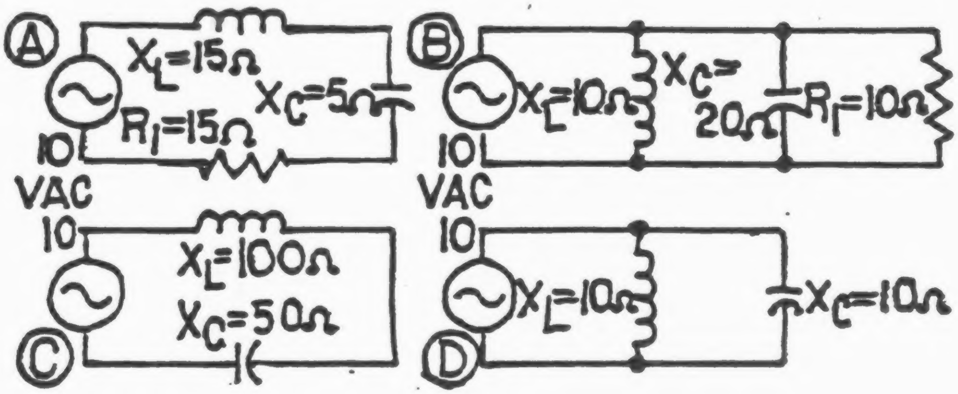
FIGURE 2

31. Utilizing figure 2, locate the schematic for a high-pass filter.
a. circuit A b. circuit B c. circuit D d. circuit E

32. Which of the circuits in figure 2 represents a band-pass filter?
a. circuit B b. circuit C c. circuit E d. both B & C


X_L=20Ω
R_1=10Ω
X_C=15Ω

33. What is the impedance of the circuit shown above?
a. 8.2 Ω b. 11.2 Ω c. 14.4 Ω d. 18.8 Ω


A
X_L=15Ω
X_C=5Ω
R_1=15Ω
10 VAC
B
X_L=10Ω
X_C= 20Ω
R_1=10Ω
10 VAC
10
X_L=100Ω
X_C=50Ω
C
10
X_L=10Ω
X_C=10Ω
D

34. Which of the circuits shown above is at resonance?
a. figure A b. figure B c. figure C d. figure D

35. An 8-henry choke is connected in series with a Z ufd capacitor.
What is the resonant frequency?
a. 26.5 Hz b. 12.65 Hz c. 40 Hz d. 400 Hz

RCL CIRCUITS

RCL : Resistor.
Capacitor.
inductor

RCL circuit: mạch điện gồm điện trở, tụ điện và cảm điện.

acceptor circuit: mạch nhận. mạch nối tiếp nhận tín hiệu ở tần số cộng hưởng

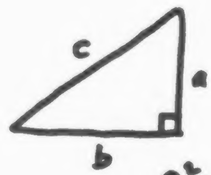
attenuation: sự giảm, chặn (âm độ và cường độ)

Band pass filter: bộ lọc băng tần

filter : bộ lọc. mạch dùng chặn, (giảm) các giải tần số đặc biệt hoặc các giải tần số.

Impedance : tổng trở (Z) điện trở tổng của mạch RCL, RC, RL mà tổng trở Z được tính bằng phương pháp vectơ tổng hay hệ thức trong tam giác vuông góc.

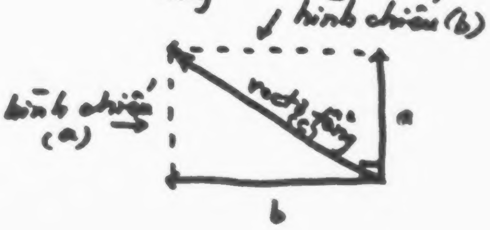
ta nhớ: bình phương cạnh huyền bằng tổng số bình phương hai cạnh góc vuông



$c^2 = a^2 + b^2$

$c = \sqrt{a^2 + b^2}$

hay



1 - RCL

dhonên trong mạch :

* **RC**

$$Z = \sqrt{R^2 + X_C^2}$$

* **RL**

$$Z = \sqrt{R^2 + X_L^2}$$

* **RCL**

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

* 3 công thức trên áp dụng cho mạch Series.

Parallel resonance:

mạch cộng hưởng song song.

Series resonance:

mạch cộng hưởng nối tiếp.

tank circuit # parallel resonance

dùng trong radio vã vô tuyến truyền hình.

* Trong một mạch RCL nối tiếp ta biết điện thế AC cung cấp vã cường độ tổng qua mạch thĩ tổng trở lõ:

$$Z = \frac{E_{apply}}{I_{line}}.$$

đơn vị của tổng trở tính bẵng Ohms (Ω) giống như R.

* Công thức tính tẫn số cộng hưởng (fr):

$$fr = \frac{1}{2\pi\sqrt{LC}} \quad \text{có: } \frac{1}{2\pi} = .159$$

$$\Rightarrow fr = \frac{.159}{\sqrt{LC}}$$

đơn vị (fr) tính bẵng Hertz viết tắt Hz.

* công thức $fr = \frac{.159}{\sqrt{LC}}$ áp dụng cho mạch song song vã nối tiếp như nhau.

* yếu tố để xác định tần số cộng hưởng (resonant frequency) fr:

* Mạch Song Song:

Khi đưa đến tần số cộng hưởng thì:

$X_L = X_C$

Z đưa đến tối đa.

I đưa đến tối thiểu

* Mạch nối tiếp:

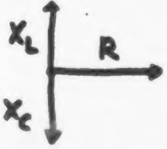
Khi đưa đến fr thì:

$X_L = X_C$

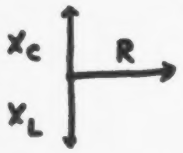
Z đưa đến tối thiểu

I đưa đến tối đa.

* Tại fr : RCL trong Series
  * X_L trên tần số cộng hưởng
  * R tương đương tại tần số cộng hưởng
  * X_C dưới tần số cộng hưởng



Tại fr : RCL trong parallel
  * X_C trên tần số cộng hưởng
  * R bằng tần số cộng hưởng.
  * X_L dưới tần số cộng hưởng.



* Công thức tính Z trong mạch Song Song:

$$Z = \frac{X \cdot R}{\sqrt{X^2 + R^2}}$$

mà $X = \dfrac{X_L \cdot X_C}{X_L + X_C}$

$$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

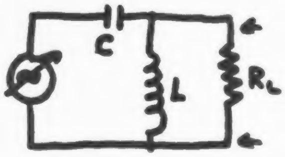
Khi tìm Z phải cẩn thận tìm $X = \dfrac{X_L \cdot X_C}{X_L + X_C}$ và $R = \dfrac{R_1 \times R_2}{R_1 + R_2}$ rồi tìm X^2 và R^2 sau đó Thay X, R, X^2 và R^2 vào công thức $Z = \dfrac{X \cdot R}{\sqrt{X^2 + R^2}}$.

3- RCL

filter circuits: mạch lọc
gồm 4 loại.

- High pass filter
- low pass filter
- band pass filter
- band Reject filter

* High pass filter:



Trong mạch nầy Capacitor nằm trong series, inductor và R Load song song. Khi thí nghiệm tìm fr Oscilloscope đặt tại R Load. fr xuất hiện khi tần số cao nhất. (khi vặn (nút) vòng tần số thấy trên màn ảnh của Oscilloscope có biên độ cao nhất là lúc mạch [redacted] đó là fr.)

Trong loại mạch nầy ta phải chú ý: $fr = X_L X_C$

nếu fr cao thì X_L cao X_C thấp $fr^{\nearrow} = X_L^{\nearrow} \cdot X_{C\searrow}$

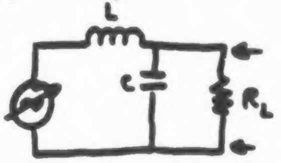
nếu $fr_{\downarrow}$, $X_{L\downarrow}$ thì $X_C^{\nearrow}$

có nghĩa fr và X_L tỷ lệ thuận và fr, X_L tỷ lệ nghịch với X_C.

Từ đây ta kiểm lại mạch High pass filter khi cộng hưởng ở tần số cao thì X_C giảm nó cho tín hiệu qua mạch.

X_L tăng nên tín hiệu không qua inductor từ đó tín hiệu qua hết R nên fr cao.

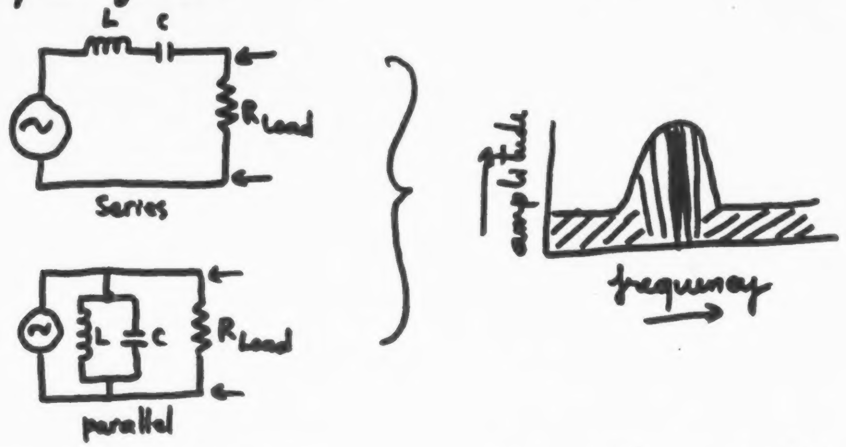
* Low pass filter:



Trong mạch nầy tần số cộng hưởng thấp: vì khi tần số fr thấp thì X_L thấp cho tín hiệu qua nó.

X_C cao nên tín hiệu không qua X_C đưa tới R Load mạch nầy fr thấp do được qua R Load.

* Band pass filter:


L
C
R_Load
Series
L
C
R_Load
parallel
amplitude
frequency

band pass filter có 2 mạch như trên.

tần số cộng hưởng fr cao ■ nhưng khó điều chỉnh.

Khi có fr và L tìm C

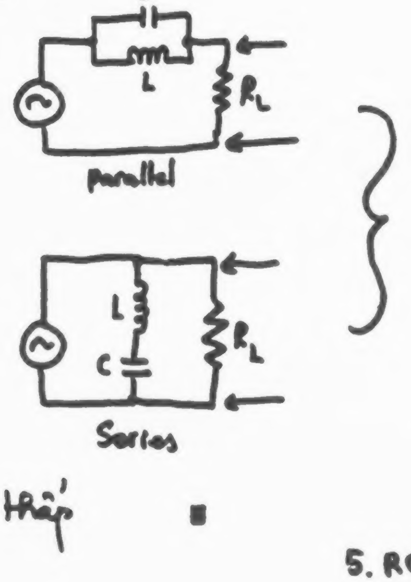
$$C = \frac{.0254}{fr^2 . L}$$

Khi có fr và C tìm L

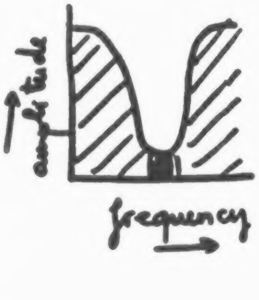
$$L = \frac{.0254}{fr^2 . C}$$

* Band - Reject filter

có 2 mạch cho band-Reject filter.


C
L
R_L
parallel
L
C
R_L
Series

tín hiệu ■ tại fr



* fr thấp ■

5. RCL.

LIII-1113-9,

电阻,电容,电感綜合电路 (RCL CIRCUITS)

技術語彙

acceptor circuit : 接收器电路

impedance : 阻抗 (Z)

resonance : 共振,共鳴,諧振

accepts : 接收

passes : 轉遞

attenuation : 衰減,电波的消失

amplitude : 振幅,幅度

band pass filter : 帶通濾波器

predetermined : 預訂的.

specific : 特定的.

band : 波段,頻帶,帶,区域

LC circuit : 电感及电容混合电路

parallel resonance : 並聯共振,並聯諧振

capacitive reactance : 容抗 (X_c)

inductive reactance : 感抗 (X_L)

RC circuit : 电阻,电容混合电路

RCL circuit : 电阻,电容,电感混合电路

reject circuit : 抑制(器)电路

block : 闭塞,闭塞(段)(裝置)

RL circuit : 电阻电感电路

series resonance : 串聯共振,电压共振.

tank circuit : 諧振电路,槽路

tuned : 已調諧的.

I.F 中頻 (intermediate frequency.

align : 校正,調整,調準.

response curve : 感应曲线.

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reactance: 电抗，誘導抵抗，感应
抵抗

appears: 顯现出.

frequency selective circuits:
頻率选擇电路

filter: 濾波器

high-pass filter: 高通濾波器

shunted: 被導入側线，避開，分路

low-pass: 低通.

band-reject filter: 带阻濾波器

product: 積(數学用語)，生產.

chock: 抗流圈，扼止，抑止